JOURNAL OF THE SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS

Image-Orthicon Film Pickup

Shooting Live Television Films

Reciprocity-Law Failure

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Automatic Threading Camera

Animation Stand

American Standards

73d Semiannual Convention • April 27–May 1, 1953 • Los Angeles

JANUARY 1953

Society of Motion Picture and Television Engineers
JOURNAL VOL. 60 JANUARY 1953 NO. 1

Subscription to nonmembers, $12.50 a year; to members, $6.25 a year, included in their annual membership dues; single copies, $1.50. Order from the Society's General Office. A 10% discount is allowed to accredited agencies on orders for subscriptions and single copies. Published monthly at Easton, Pa., by the Society of Motion Picture and Television Engineers, Inc. Publication Office, 20th & Northampton Sts., Easton, Pa. General and Editorial Office, 40 West 40th St., New York 18, N.Y. Entered as second-class matter January 15, 1930, at the Post Office at Easton, Pa., under the Act of March 3, 1879.

PRINTED BY MACK PRINTING COMPANY, EASTON, PA.

Film Projection Using Image-Orthicon Cameras

By R. D. CHIPP

Presented here are the results of over a year's use of image-orthicon cameras for all film transmitted by television station WABD, New York, totaling approximately 2000 hr. In addition to brief consideration of the technical problems encountered, cost, reliability, convenience and other operational factors are discussed.

Over the past two years there have been a number of discussions concerning the use of the image-orthicon pickup tubes for the transmission of film.[1-3] These have covered, in some detail, the characteristics of such tubes, and the basic design of film projectors for television. They have also suggested some of the advantages and the disadvantages of film cameras using image orthicons. The Research Division of the Allen B. Du Mont Laboratories, Inc. commenced tests of this type of pickup in 1948. By early 1950 image-orthicon techniques were such that practical operating tests were in order. WABD in New York then installed one unit. The results led us to conclude that, for the broadcasting of "run-of-the-mill" available film, often without system preview or rehearsal, the image-orthicon camera had several desirable features. By early 1951, WABD was using Type 5820 Image Orthicons for all film transmission. It should be emphasized that we were primarily concerned with consistently good reproduction of films of uncertain vintage and quality, rather than with excellent reproduction of a few films especially made and processed for television.

Presented on October 6, 1952, at the Society's Convention at Washington, D.C., by R. D. Chipp, Director of Engineering, Du Mont Television Network, 515 Madison Ave., New York 22, N.Y.

Projectors

The WABD projection room was originally laid out in March 1946, and equipped with two Simplex 35mm and one Victor 16mm projectors. These had been modified for 2–3–2–3 pull-down. In 1948 we added two Du Mont-Holmes, Model 5130C, 16mm television projectors. These were placed and mounted as shown in Fig. 1. Mounting details for the 16mm projectors, which weigh approximately 300 lb, are shown in Fig. 2. The concrete base weighs approximately 500 lb and provides extremely steady operation. Tests for picture stability are better than the proposed RTMA/SMPTE specifications, and no mechanical changes have been necessary to adapt any of the projectors to image-orthicon use.

Cameras

The cameras are standard Du Mont equipment, Model TA-124, normally

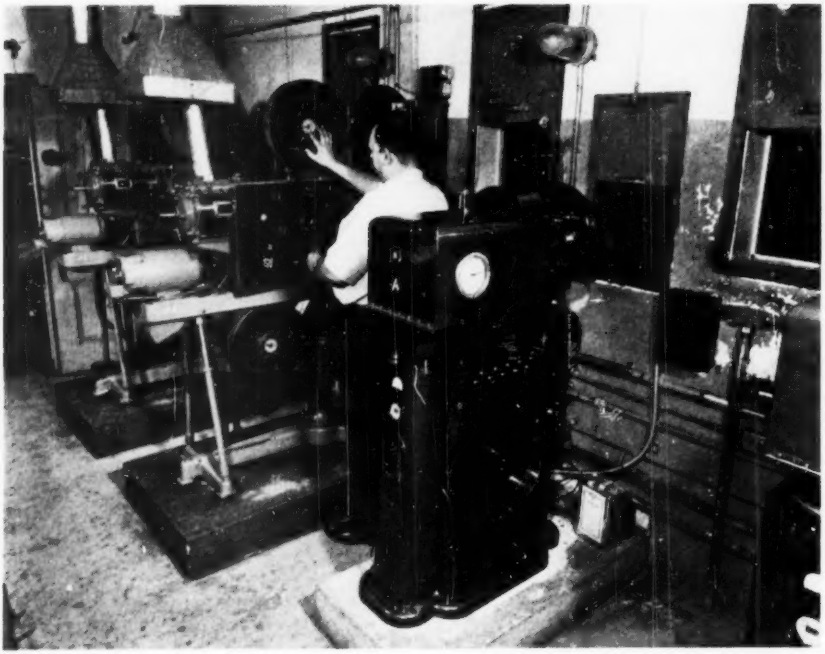

Fig. 1. WABD projection room.

Fig. 2. Mounting details of 16mm projector.

used in studios and in the field. Each is equipped with a 90-mm $f/3.5$ lens, and so placed with respect to the screen that the photo cathode is $18\frac{3}{4}$ in. distant. The only change required was reversal of the horizontal sweep, which is accomplished by switching two leads on the deflection yoke. The cameras are aligned and adjusted in a conventional manner, using the "knee-of-the-curve" technique.

Screen

The original projection room was equipped with iconoscope cameras mounted on tracks. These were moved into position in front of any one of the four available projectors, which were separated from the cameras by a fire wall. This was a conventional arrangement. In order to substitute image-orthicon cameras, with no disruption of a heavy operating schedule, it was decided to retain the same method of camera mounting. This, in turn, precluded use of direct projection, and indicated use of an intermediate screen between the projector and camera. The 16mm projectors, originally

equipped with 4-in. lenses for iconoscope use, were refitted with 2-in. $f/1.9$ lenses to produce a $3\frac{3}{8}$ in. $\times$ $4\frac{1}{2}$ in. image on the screen. The 35mm projectors, originally equipped with $8\frac{1}{2}$-in. lenses, were refitted with 5-in. $f/1.9$ lenses. Tests of many screen materials were made. Among the materials tested were tracing paper, standard rear-projection material, experimental translucent plastic, latex, ground glass and flashed opal. In view of the relatively small image size, most of these materials were discarded because of excessive grain. From the standpoint of minimum grain and minimum light dispersion, latex appeared to be superior to other materials. However, it aged rapidly, changed color, and was difficult to keep clean. Ground glass, which did not have these undesirable characteristics, was finally selected as satisfactory for practical use. A metal hood is used to prevent stray light from reaching the screen from either side. Figure 3 shows the hood from the projection-room side, and Fig. 4 from the camera side. Note in Fig. 4 the detent mechanism which permits the rapid movement and precise location of the cameras.

Light Reduction

As is well known, substitution of image orthicons for iconoscopes requires a substantial reduction of the light intensity to secure operation of the pickup tube at the proper point on the characteristic curve. Many means of accomplishing this have been suggested. We elected an extremely simple method: the substitution of a 300-w projection lamp for the usual 1000-w lamp. These lamps are operated at 90 v instead of the nominal 115 v. Screen brightness measurements, with no film in the gate, showed 125 ft-L, uniform within approximately ± 10 ft-L. In order to reduce the light output of the 35mm projectors to equal that of the 16mm projectors, we dropped the arc current from 25 amp to 20 amp and added neutral density filters having 40% transmission. With the opening of the Du Mont Tele-Center in New York, new and less expensive light sources, now under investigation, will be used.

Operation and Adjustment

Image-orthicon cameras are equipped with vertical and horizontal saw-tooth controls for shading. We have found that these can be set for a particular pickup tube and specific light input, and no shading adjustments need be made during the running of a film. Figure 5 shows the operating position at WABD. One operator handles two cameras, plus remote control of a flying spot scanner and automatic slide changer. The Du Mont cameras incorporate a black peak clipper as well as a white clipper. The white clipper is set so that normal white is never saturated, but extreme highlights may be reduced in amplitude. The black peak clipper is set so as to maintain constant black level and thus maintain standard setup. With most film, and a Type 5820 Image Orthicon, the camera lens may be stopped down to $f/5.6$. When using a 5826, a typical aperture is $f/3.5$. These lens settings are average. We have observed that the sensitivity of image orthicons of equal age may vary from tube to tube by a factor of 5. Sensitivity may also change with age by a factor of as much as 10. These variations are equalized by changing the lens stops. As indicated above, we have used both 5820 and 5826 for film transmission. The 5826 provides improved signal-to-noise ratio, and a somewhat better gray scale. Under some circumstances, with very dark scenes or very dense film, some adjustment to the iris is made. Also on occasion video gain and target voltage may be varied in order to avoid excessive black saturation. However,

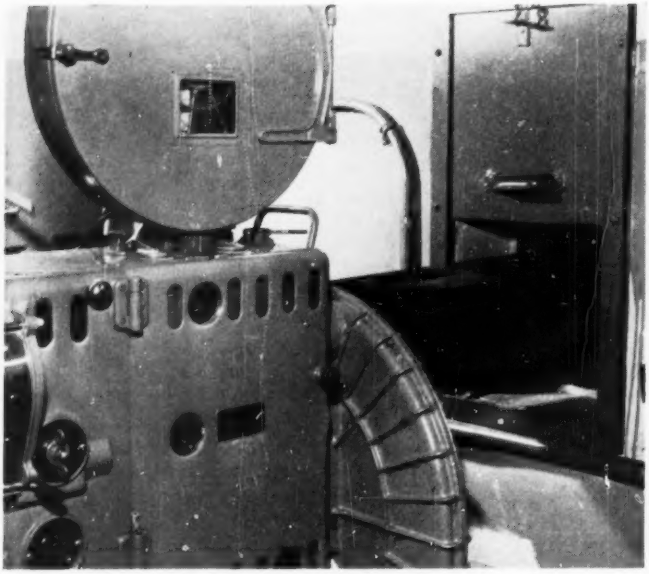

Fig. 3. Light shield in front of 35mm projector.

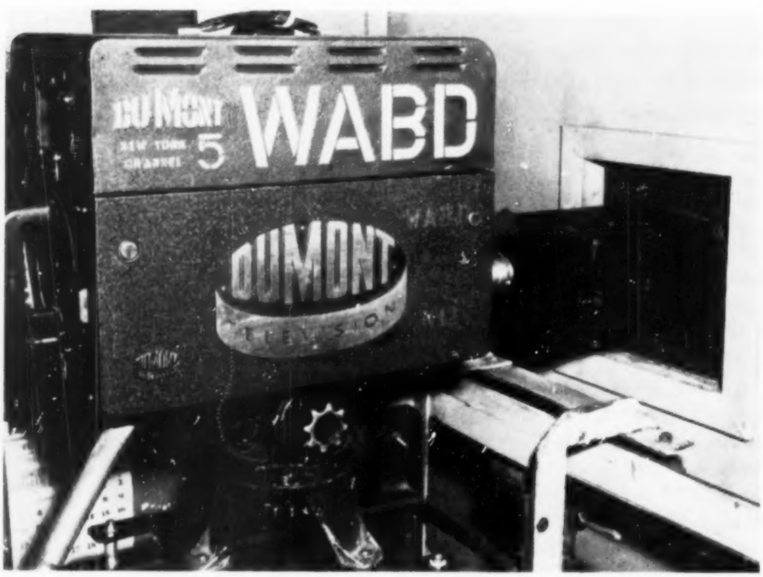

Fig. 4. Light shield on camera side of fire wall.

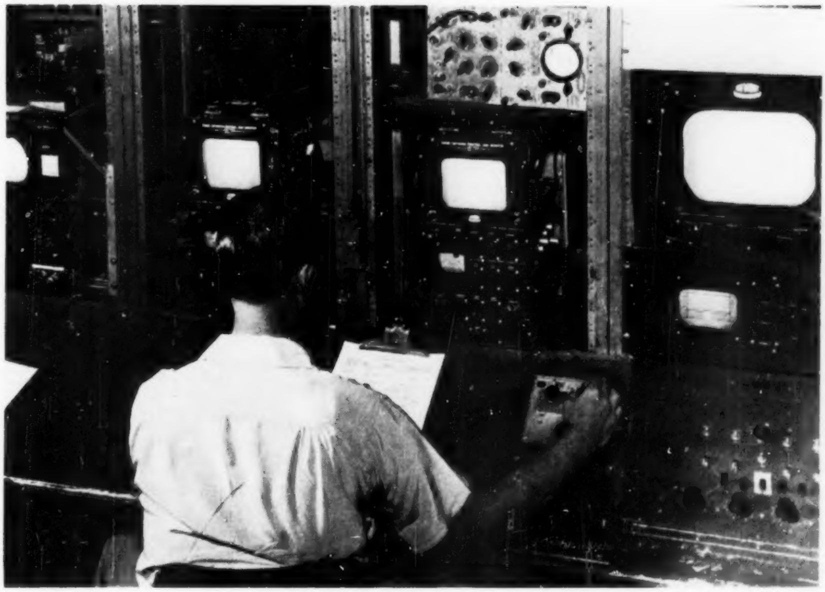

Fig. 5. Film camera operating position.

we have found that very little "gain-riding"* is necessary on average film.

Cost

There has been considerable discussion of the cost of using image orthicon tubes for film projection. Table I shows the life records of iconoscopes used in 1948, 1949 and part of 1950, together with those 5820 Image Orthicons used for film from mid 1950 to early 1952. Experience to date indicates that 5826 and 5820 Image Orthicons have comparable life when used for film. The average hourly costs, based on list prices, are 25.7¢ and 83.8¢, respectively. Table I shows also the hourly cost of projection lamps, which is believed in this instance to be of significance.

The iconoscopes were generally removed from service for loss of resolution

* "Gain-riding," an expression which originated in sound broadcasting, originally referred to the frequent and sometimes continuous adjustment of audio amplifier gain controls to compensate for changes in program volume. The term has carried over into television broadcasting and may refer, in addition to its original meaning, to adjustment of the various video controls to compensate for changes in picture content.

Table I

	Image orthicon (5820)	Iconoscope (1850A)
Hours	2200	1256
	2660	1481
	765	1533
	665	1441
	1407	2660
	666	1876
	804	3590
	2285	3003
Average hours	1431.5	2102.5
Cost/hour	$0.838	$0.257
Proj. lamp cost/hour	0.128	0.660
Total cost/hour	$0.966	$0.917

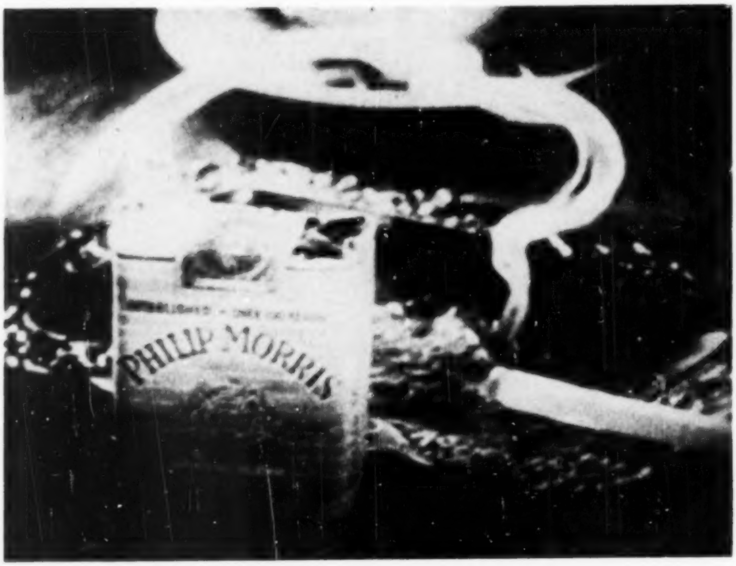

Fig. 6A. A frame reproduced on an iconoscope system.

Fig. 6B. A frame reproduced on an iconoscope system.

Fig. 7A. The same frame as in Fig. 6A reproduced on an image-orthicon system.

Fig. 7B. The same frame as in Fig. 6B reproduced on an image-orthicon system.

and low output, whereas the orthicons are generally removed, as is the case in studios, for "sticking."* Note that when tube and lamp costs are added, the expense of using iconoscopes is 92¢ per hour and the expense of using image orthicons is 97¢ per hour.

Conclusion

Admittedly, an iconoscope chain, carefully modified and maintained and skillfully operated, can produce extremely good pictures from good film. However, it has been our experience at WABD that the image orthicon camera can also produce good pictures, with no operational difficulty, from nearly all grades of film. Moreover, to the broadcaster, there are certain other advantages that may be gained from the use of image orthicons. Technical man-hours used for system previews and film rehearsals may be eliminated. When all cameras in a station are of the same type, maintenance procedures may be standardized and simplified. Further, spare parts and tube inventories may be reduced. Finally, the operating cost is not appreciably in excess of that of the iconoscope. Figures 6A and 6B are frames from film reproduced on an iconoscope system, and teletranscribed directly from the line. Figures 7A and 7B are the same frames from the same film, as reproduced on an image orthicon system and teletranscribed on the same facilities. Although many conclusions may be drawn from careful analysis of these pictures, it may be said that the second picture does not suffer by comparison.

References

1. R. L. Garman and R. W. Lee, "Image tubes and techniques in television film camera chains," *Jour. SMPTE, 56:* 52–64, Jan. 1951.
2. K. B. Benson and A. Ettlinger, "Practical use of iconoscope and image orthicons as film pickup devices," *Jour. SMPTE, 57:* 9–14, July 1951.
3. P. J. Herbst, "Televised film," *Broadcast News*, May-June 1952.

* "Sticking" refers to a phenomenon which occurs in image orthicon tubes, wherein, when a camera is panned from one scene to another, the first scene is briefly retained on the photocathode. As tubes age, the period of retention increases, and the tube is finally no longer satisfactory for broadcast use.

Discussion

George Lewin (Signal Corps Photo Center): If there's a problem due to grain of the screen material, can't that be eliminated by just using a larger image on the screen?

Mr. Chipp: Yes, it could. Perhaps I didn't stress sufficiently the physical problem that we had in using an existing location. Now, when we move to our new studios — if we do not use direct projection into the tube, we will use a larger screen.

Anon: I wonder if you must form a first image on the screen. I'm not sure what your optical system is, but it would seem that the screen can be eliminated.

Mr. Chipp: Well, the optical system is conventional in both the projector and the camera, so that we form an image on the screen....

Anon: There is then no reason really to form a first image. All you need is a field lens between two lenses.

Mr. Chipp: Yes, that's probably true. I think investigation might show the field lens would be something rather expensive.

Anon: Also, a field lens could be very cheap and very simple as long as it's in the plane of the first image. Every microscope uses this in almost every optical system. It's used to carry an image through several lenses.

Mr. Chipp: That might be the case. We haven't fully investigated that.

Barton Kreuzer (RCA, Camden, N.J.): What do you do in case of stills?

Mr. Chipp: We use the flying-spot scanner for all slides. You didn't see the scanner in the picture, but the controls for the scanner are next to the video operator below the orthicon camera controls. In the case of a program where there may be a series of titles, we use title cards in the studio. They're picked up by the studio image orthicon.

Mr. Kreuzer: In these iconoscope comparisons, did the iconoscope chain have the latest improvements in it that were described to the industry and pretty generally accepted about six or eight months ago?

Mr. Chipp: Yes, to the best of my knowledge.

Shooting Live Television Shows on Film

By KARL FREUND

Experience in shooting live television shows on film is described, in which three motion picture cameras were used instead of television cameras, with overhead lighting and in the presence of an audience. Subject contrast was measured by means of a flare-free brightness photometer.

There are various methods by which programs are produced for home television: (1) the direct live show with audience participation, (2) the same show kinescope recorded, (3) motion picture films formerly made for theater exhibition and (4) motion pictures especially made for television by the use of one camera and lights properly placed for each individual camera setup.

In 1951 Desilu Productions (Desi Arnaz and Lucille Ball) asked me to be Director of Photography for the *I Love Lucy* audience-participation show, introducing for the first time a deviation from standard procedure. Television cameras were to be replaced by three motion picture cameras to provide more flexibility in editing and nation-wide better photographic quality than that accomplished by kinescope recording.

Presented on October 7, 1952, at the Society's Convention at Washington, D.C., by John W. Boyle for the author, Karl Freund, Director of Photography, 15024 Devonshire St., San Fernando, Calif.

Being aware that this was a step in the right direction and a challenge to a motion picture camerman, I accepted the assignment without realizing that besides the usual problems connected with photographing motion pictures, I would inherit additional troubles photographing a live television show.

A regular motion picture studio was equipped with bleachers to accommodate approximately 300 people and a series of directional microphones and loudspeakers installed overhead (Fig. 1). The lighting for the sets had to be placed above, to give the audience a clear view of the show and also to give the cameras 100% mobility without interference of floor cables.

Motion picture technicians have expressed a special curiosity as to why it was decided to present the *I Love Lucy* show before a live audience. It seemed unusual to make so many painstaking preparations to please a group of only 300 spectators each week when the show was aimed at an ultimate audience of many millions. And yet the one thing which may be the key to the popularity

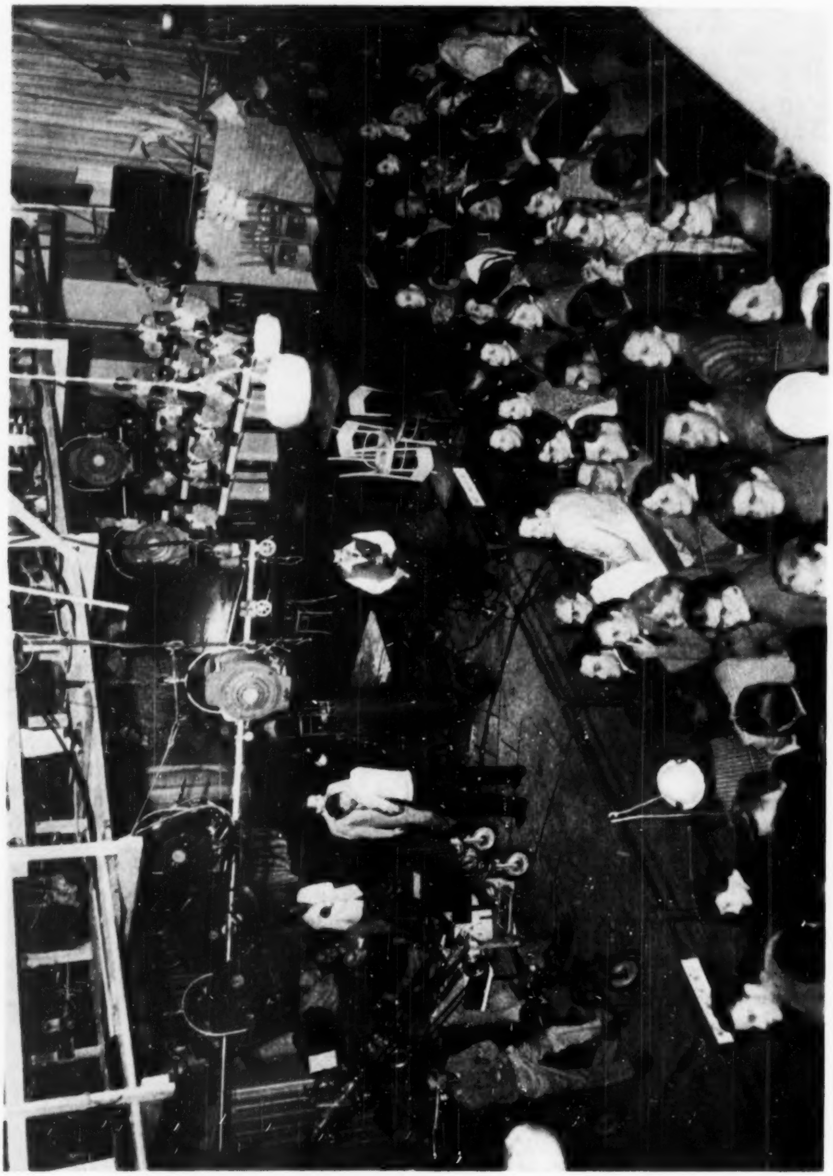

Fig. 1. Regular motion picture studio equipped with bleachers to accommodate approximately 300, with directional microphones and loudspeakers installed overhead.

Fig. 2. Lights placed above the set to give the audience clear view of show and to give the cameras 100% mobility.

of the program is the long accepted fact that an audience has an astonishing effect in stimulating performers. It also has been generally acknowledged that laughs dubbed in later sound highly artificial.

It naturally would have been comparatively more simple to produce *I Love Lucy* in routine fashion, and certainly a better guarantee of good photographic and composition results would have been accomplished through ordinary methods of setups and close-ups with as many retakes as necessary.

Since it was necessary to place the lights overhead (Fig. 2) and at the same time do photographic justice to the actors, the natural thing was for me to begin with a series of tests. After projecting these tests in the laboratory projection room, I found they had the quality I was accustomed to when photographing motion picture comedies, but when viewed over a closed television circuit, these prints showed *too* much contrast.

Seeking an explanation for this, I was briefed by television engineers and informed that the iconoscope tube, which is most used for monochrome film telecasting, has certain limitations not yet overcome by the manufacturer and I was cautioned to keep this in mind and reduce my lighting contrast and suppress the brightness range considerably. Next, I familiarized myself with current television publications of film manufacturers from which I quote:*

* "The Use of Motion Picture Films in Television," Eastman Kodak Co., 1949, p. 12.

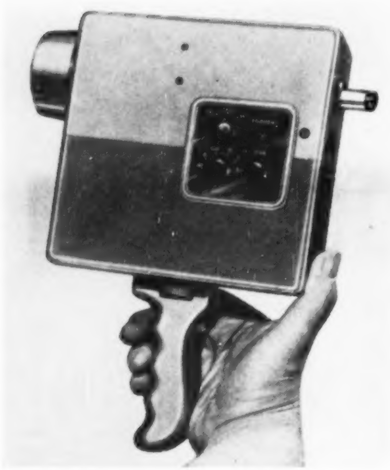

Fig. 3. Brightness spot meter to measure brightness of a very small area at any distance from 4 ft to infinity.

"The most notable departure from standard motion picture technique in making films for television use is that relating to the subject lighting contrast which is required. The limited range of brightnesses which can be reproduced as satisfactory tone scale values in the television system imposes restrictions on the range of brightnesses which can be effectively reproduced on a receiver screen from a subject being televised."

It should be noted that the term "lighting contrast" does not mean subject contrast or subject brightness range.

The true subject contrast or subject range is usually much higher than the lighting contrast since it takes into account the different reflectances of the various elements of the scene. It can be measured accurately only by means of a flare-free telescopic type of brightness photometer (Fig. 3) which measures an extremely small area and which allows the instrument to be situated at a sufficient distance so as not to obstruct any light falling on the subject. In film telecasting the subject is an image on film, which means that the density range must not exceed a certain value if good tone reproduction is to be obtained both in highlights and shadows.

I should quote further:

"The question which immediately arises is what method to use in order to obtain the desired density compression in the positive print. Upon first examination it might appear that this might be accomplished equally well in at least three different ways:

(1) In exposing the original negative, use a subject lighting contrast which is considerably lower than that which is normally used for conventional black-and-white motion picture photography, and process both the negative and print in the normal way.

"(2) Use normal lighting contrast and exposure but alter the processing conditions of negative or positive or both, to obtain an overall reproduction gamma which is lower than normal.

"(3) Use normal lighting contrast and exposure, process the negative and positive in the usual manner, but make the print 2 or 3 or more printer steps lighter than what would be desirable if the print were to be used for normal projection purposes."*

In shooting *I Love Lucy* I selected the first method since this involved no departures from standard practice in processing laboratory operations.

One important point I want to mention at this time is that in viewing the first show over my own television receiver, I realized that I do not have complete control of the end results. There is an engineer in every control booth when the show is televised who can change the screen image according to instructions and depending upon the condition of the equipment he has to work with; besides, there are millions of individual television owners who also have control over the quality of the final product on their own screens. Disturbed by all these condi-

* *Ibid.*, p. 13.

REHEARSAL SCHEDULE FOR "I LOVE LUCY" #46

Friday, September 5, 1952

8:00 A.M.		ELECTRICAL	GRIPS
		Gaffer Best Boy 3 Operators 2 Dimmer Men 1 Gen. Oper. (GSS) 1 Stand-By Laborer	Noble Craig 2nd Grip
9:00 A.M.	Karl Freund Jack Owen		
10:30 A.M.	2 Cable Men 2 Stand-ins		
11:00 A.M.	3 Asst. Cameramen 1 Mike Man		
11:30 A.M.	3 Dolly Grips		
11:45 A.M.	3 Camera Operators		
12:00 Noon to 12:30 P.M.	Lunch for early crew		
12:00 Noon to 3:00 P.M.	REHEARSAL WITH CAMERAS		
3:00 P.M. to 4:00 P.M.	Lunch for late crew and cast		
4:00 P.M. to 7:00 P.M.	REHEARSAL WITH CAMERAS		
7:00 P.M. to 8:00 P.M.	DRESS REHEARSAL — CAST		
		N. Craig F. Jenkins Best Boy Jack Owens	

Fig. 4A. Typical schedule for first day rehearsal with cameras.

SHOOTING SCHEDULE FOR "I LOVE LUCY" #46

Saturday, September 6, 1952

12:30 P.M.		**ELECTRICAL**	**GRIPS**
		Gaffer Best Boy 2 Operators 1 Floor Man 2 Dimmer Men 1 Gen. Oper. (GSS)	Head Grip Floor Grip
12:30 P.M.	Hairdresser—B. French		
1:00 P.M.	3 Asst. Cameramen	**SOUND**	
		Mixer—1:30 P.M. Mike Man—1:00 P.M. 3 Cable Men—1:00 P.M.	3 Dolly Grips —1:00 P.M.
2:00 P.M.	Karl Freund		
2:00 P.M. to 5:30 P.M.	REHEARSAL WITH CAST		
4:00 P.M.	1 Camera Loader-Recorder 1 Makeup Man—Hal King		
5:30 P.M. to 6:30 P.M.	Dinner for cast and crew		
6:15 P.M.	MUSIC BALANCE and RECORDING from stage		
6:30 P.M. to 7:15 P.M.	TALK THRU—Conference with Bill Asher (all crew except sound man)		
7:15 P.M.	Doors Open		
7:45 P.M.	Warm-up		
8:00 P.M. to 9:30 P.M.	SHOW		
9:45 P.M.	Start pickup shots		

Fig. 4B. Typical schedule for second day rehearsal with cameras.

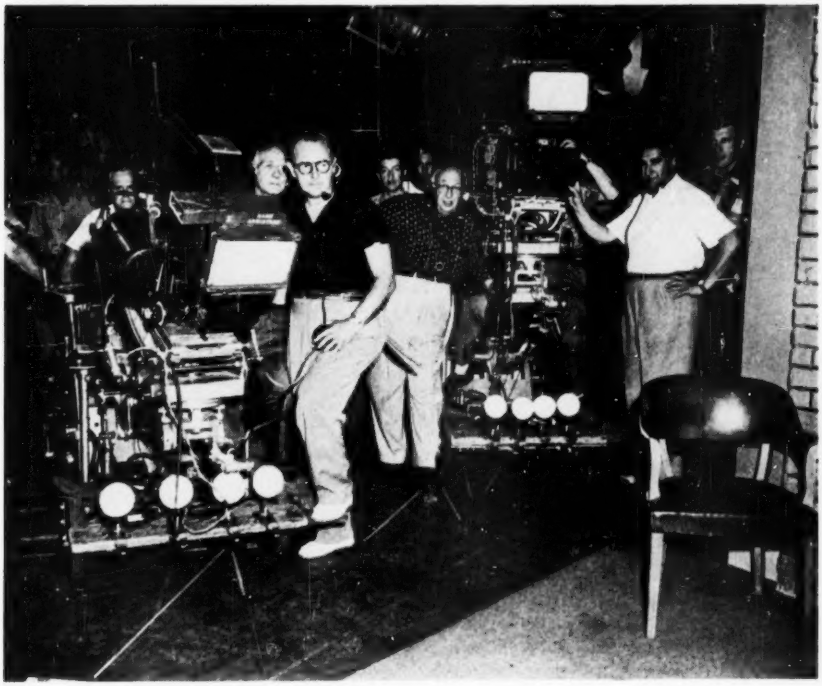

Fig. 5. The only floor lights used are mounted on the bottom of each camera dolly; movements of the dollies are marked on floor for each individual scene.

tions, I was advised by television authorities to be patient, compromise with the young industry and trust in future developments which in time would give us the quality we are accustomed to seeing in motion pictures.

The following is an outline of the practice established in shooting the *I Love Lucy* and *Our Miss Brooks* shows.

Four days are required to line up each weekly show — two days of which are taken by the director and the cast for rehearsals. At the end of the second day I have an opportunity of seeing a run-through which enables me to make notes and sketches of positions to be covered by the cameras and to instruct the electrical crew as to where the lights are to be placed. The last two days are occupied by rehearsals with cameras. Figures 4A and 4B show typical schedules for the two days of rehearsal with cameras. These schedules have to be kept up to the minute by everybody concerned, including the cast, because a show with audience participation must go on at a specified time. The actual shooting time for the entire show is approximately one and a half hours.

The cameras used are three BNC Mitchells with T-stop calibrated lenses on dollies. The middle camera usually covers the long shot using 28-mm to 50-mm lenses and the two close-up cameras 75° to 90° apart from the center camera using 3- or 4-in. lenses, depending upon certain requirements for coverage.

Mounted on the bottom of each camera dolly and above the lens, controlled by dimmers, are the only floor lights used

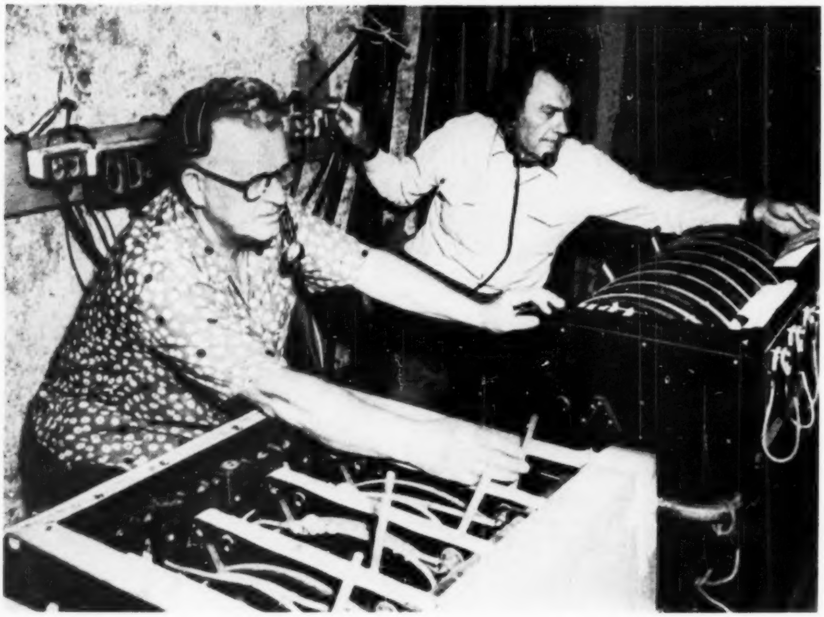

Fig. 6. Electricians handling the dimmer board.

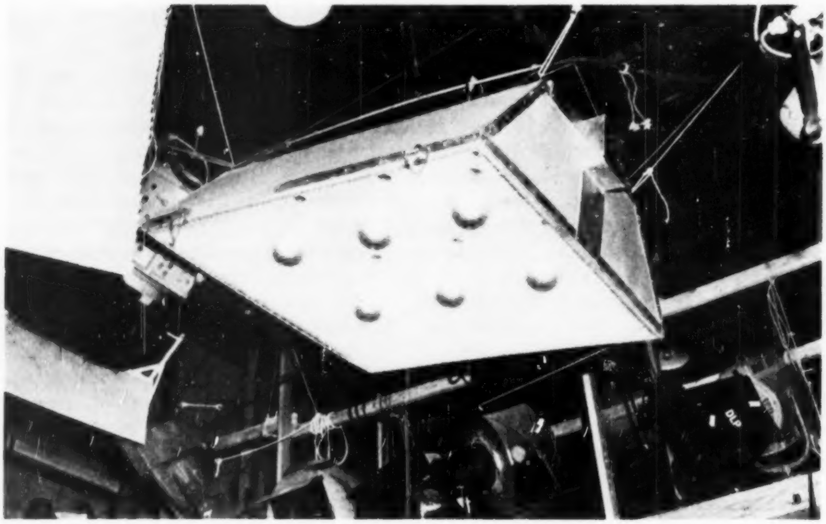

Fig. 7. Overhead lights using 6 1-K silver-coated lamp bulbs for indirect lighting.

(Fig. 5). A crew of four men — the operative cameraman, assistant, grip and cable man — is required on each camera, and coordination among them is essential, unlike in television where the responsibility lies with only one man handling his own camera movements, focusing, tilting and panning and having the additional advantage of viewing his results immediately.

Each movement of the dollies is marked on the floor for each individual scene (Fig. 5). The entire crew uses an intercommunication system, since all the movements of the camera are cued from the monitor box. I personally use a two-circuit intercommunicator to enable me to talk separately to the monitor booth and the camera crew on one, and to the electricians handling the dimmers and the switchboard on the other (Fig. 6).

It is a noteworthy coincidence that just 30 years ago this month, I introduced the moving camera to the motion picture industry in the German picture *Last Laugh*. If I had known then what trouble I was storing up for myself, especially in the *I Love Lucy* show where the cameras are moving constantly, I certainly would have thought twice before starting this innovation.

Since the audience is lost at the end of each show, retakes are not desirable because laughs would then need to be dubbed in. Retakes are therefore made in emergency cases only. Even better-lit close-ups, taken by a single camera with properly placed lights, had to be discarded. Cutting these so-called "glamour" close-ups into the picture proved unsatisfactory as it was found that they stood out like a sore thumb. Retakes were made when necessary, and the same lighting used as during the show except for minor unnoticeable changes.

The illumination level of 250 foot-candles measured with the incident light meter and the lighting contrast of 2 to 1 are maintained practically over the entire set.

The lens T-stop is 4.5. The permissible brightness range which is governed by both the illumination and the reflecting power of the various parts of the scene should not exceed a 20 to 1 ratio, so special attention is paid to makeup, dresses, props and color of the sets. The best reproduction of face tone quality I experience with makeup two to three shades darker than usually applied in motion pictures.

The following materials were of Eastman Kodak manufacture: Plus X, 35mm, type 5231 Negative developed to gamma 0.68; print on Fine-Grain Release Positive, 35mm, type 5302, gamma 2.40; Fine-Grain Duplicating Positive, 35mm, type 5365, gamma 1.40; Fine-Grain Dupe Negative, 16mm, type 7203, gamma 0.55; Fine-Grain Release Positive, type 7302, 16mm, gamma 2.15.

New overhead lights were developed with six 1000-watt silver-coated lamp bulbs for indirect lighting (Fig. 7). For front key-light, converted 5000-watt pans with sleeves to accommodate diffusing material are used (Fig. 8); otherwise there is no deviation from standard motion picture lighting equipment.

All the lights are preset for each individual scene and changed accordingly by signals to the switchboard operator. Experiments are now under way to eliminate many individual spot lights by replacing them with sealed beam lights and better lighting equipment is in development to enable easier operation for this type of show.

To have had the opportunity to play a part in the success of the *I Love Lucy* show which is now rated the No. 1 television show in the nation assures me that the efforts to overcome the handicaps have not been in vain, and the results accomplished are comparable to motion picture photographic quality where comedy treatment of lighting is required.

In conclusion, I want to give credit to the producer, cast and crew, Dr. Nor-

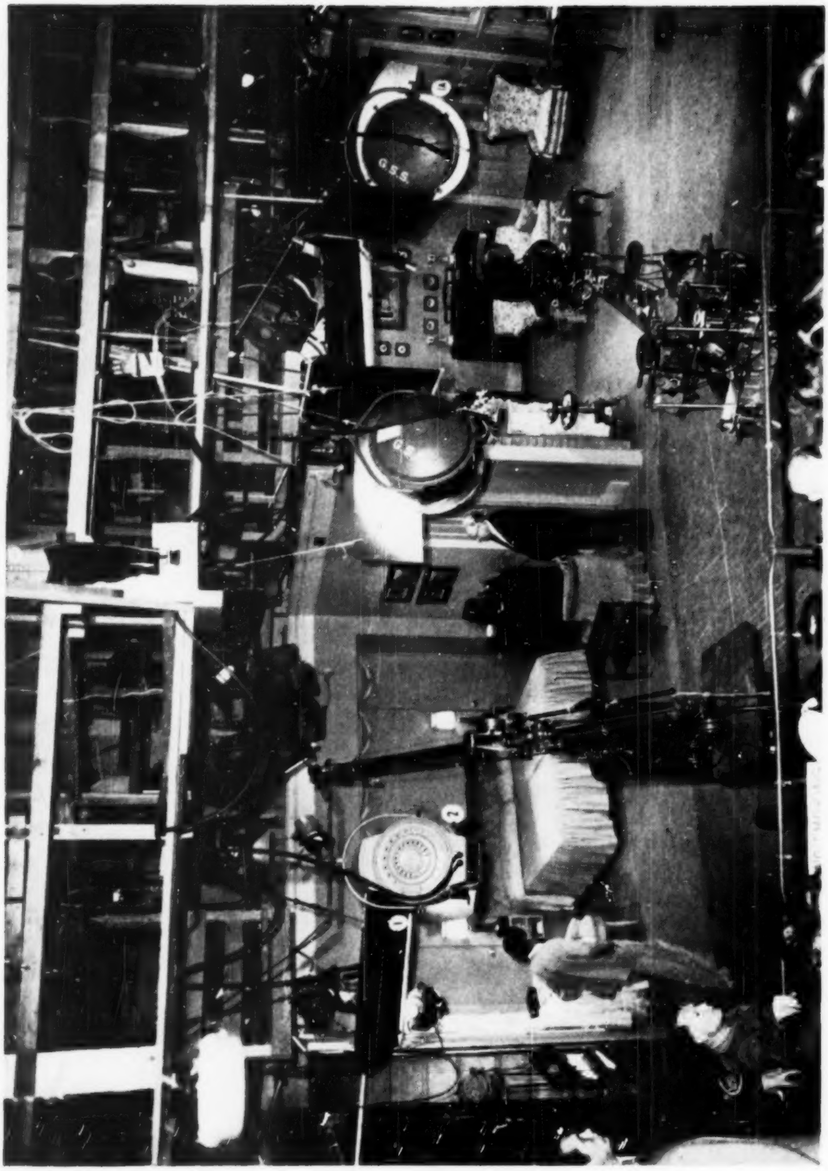

Fig. 8. Front key-light, converted 5-K pans with sleeves to accommodate diffusing material.

wood Simmons of Eastman Kodak, Mr. Herb Pangborn of CBS and the staff of Consolidated Laboratories. Through their lively cooperation I am able to achieve the best photographic results.

Discussion (replies written by the Author)

Robert M. Fraser (National Broadcasting Co., New York): How much time is spent in editing? While production time is four days up to the time of shooting there must be considerable time, of course, spent after the shooting.

Dr. Karl Freund: Four days are not required for shooting; as mentioned, only two days are used for rehearsal with actors and two days for rehearsal with cameras. The actual shooting time is approximately one hour and fifteen minutes. This includes reloading the cameras, makeup changes and costume changes of the cast. The editing time is approximately four weeks.

Mr. Fraser: Is the sound recorded after the show, the musical bridges, for example, which are used evidently to cover up time lapses in the actual show?

Dr. Freund: The sound is recorded magnetically and the musical bridges are recorded before the actual shooting of the show to save expenses for special orchestra sessions.

R. T. Van Niman (RCA Victor Div., Camden, N.J.): How many weeks ahead do they shoot the shows before they are shown on television screens?

Dr. Freund: Shows you see on a television screen were shot six weeks ahead.

Practical Aspects of Reciprocity-Law Failure

By J. L. TUPPER

The occasional failure of sensitometric data to provide a reliable indication of the practical performance of photographic materials is usually attributable to the failure of the reciprocity law. The effect of reciprocity-law failure on the characteristic D-log E curves of various films is shown graphically. The influence of developing time and of the temperature of the film on the effectiveness of exposure at various intensity levels is discussed. Certain generalizations are made about the failure of the reciprocity law which may be helpful in reconciling differences between laboratory measurements and the results obtained in motion picture practice.

With the general acceptance of the methods of photographic sensitometry in the control of the uniformity of production of motion picture negatives, prints, duplicates and sound records, and in the analysis of new techniques and processes, there has been a growing concern about occasional failures of this tool to provide a reliable indication of the performance of photographic materials in practice. Similarly, there is the problem in high-speed photography of reconciling sensitometric data obtained under standard conditions with the effective characteristics of the material realized at extremely short exposure times. There are many possible causes of these discrepancies, but the one most frequently responsible is the failure of the reciprocity law. It is only through an understanding of the practical manifestations of this phenomenon that sensitometry can be utilized most effectively in the wide variety of applications to which it may be put.

An assumption which is frequently made in the substitution of a sensitometric test pattern composed of systematically graduated exposures for an actual pictorial or sound record is that there will be a one-to-one correspondence between the densities of the developed images resulting from equal exposures, regardless of the mechanism used in impressing the exposures on the sensitive material, or of the intensity and time components of the exposures, provided their products ($I \times t$) are in all cases equal. However, the density obtained is not uniquely determined by the value

Communication No. 1518 from Kodak Research Laboratories, a paper presented on April 23, 1952, at the Society's Convention at Chicago, by J. L. Tupper, Eastman Kodak Co., Kodak Park Works, Rochester 4, N.Y.

of the exposure, but it usually depends upon the individual values of I and t. This failure of *time* and *intensity* to act reciprocally is a consequence of the dependence of the latent-image-forming process on the rate at which the exposure event takes place.

Latent-image theory suggests a mechanism which explains the normal decrease in efficiency of latent-image formation when the rate at which energy is received exceeds or falls below a certain optimum value. The tendency for latent images formed at high intensities to be less readily developable than those formed at low intensities has been explained on the basis of differences in the spatial distribution of the latent-image nuclei in the silver halide crystal. From a practical point of view, however, it must be reported that few photographic materials are affected exactly alike by changes in the parameters of *time* and *intensity* in the exposure equation. Strictly, in discussing reciprocity failure, each material should be treated as a special case. On the other hand, there are certain typical patterns which characterize many films used in motion picture photography, and it is those which will be used to illustrate the practical significance of this phenomenon.

The conventional method of representing the effect of reciprocity-law failure is a curve in which the logarithm of the exposure required to produce a particular density is plotted as a function of the logarithm of the intensity of the exposing light. Such a curve based on a density of 1.0 is shown in Fig. 1. The parallel straight lines inclined at 45° are lines of constant exposure time. These are merely parts of the reference framework. Curve X is the reciprocity-failure curve. If the reciprocity law held, that is, if the photographic effect depended only on the product of *time* and *intensity*, this curve would appear as a straight horizontal line. It is seen however, that the curve is characterized by a minimum, which corresponds to the optimum intensity. The curve rises at intensity values above and below the optimum. The amount of the upward turn of the curve at the two ends of the graph is a measure of the amount of the reciprocity failure at low and high intensities. The magnitude of the low-intensity failure may be conveniently expressed in terms of the ratio of the exposure at some arbitrarily selected low value of intensity, such as that indicated at A, to the exposure at the optimum intensity level indicated at B. Similarly, the magnitude of the high-intensity failure may be expressed as the ratio of the exposure at an arbitrarily selected high intensity, C, to the exposure at the optimum intensity, B. In this example, the low-intensity failure, in terms of the ratio, A:B, is 5.3 and the high-intensity failure, ratio C:B, is 2.0. This pattern is characteristic of most negative materials; the optimum intensity is about 8 meter-candles, corresponding to an exposure time of 1/40 sec, and the low-intensity failure is greater than the high-intensity failure. Also note that at the very high intensities (100,000 meter-candles, upward), the reciprocity law appears to hold over a considerable range. The upper limit of this range has not yet been determined experimentally, although there is some evidence that it may extend well beyond 10^7 meter-candles.

Some mention should be made of differences in reciprocity failure in various types of photographic materials. In general, the greatest differences occur in the low-intensity region. This is a consequence of designing emulsions to meet the particular requirements of the various systems in which they are to be used. A large amount of low-intensity reciprocity failure is desirable if the material is to be used, for example, in motion picture photography, where camera exposures are made at 1/25 sec, or less, since the lower sensitivity

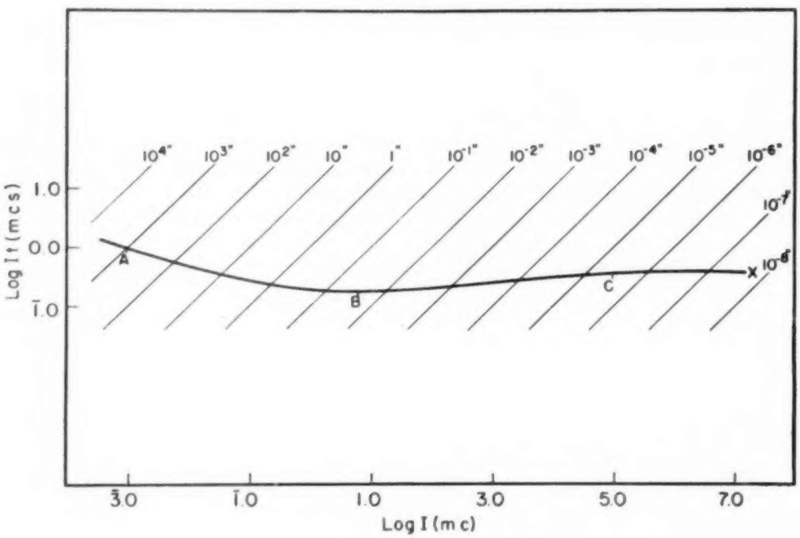

Fig. 1. Reciprocity-law-failure curve based on a density of 1.0.

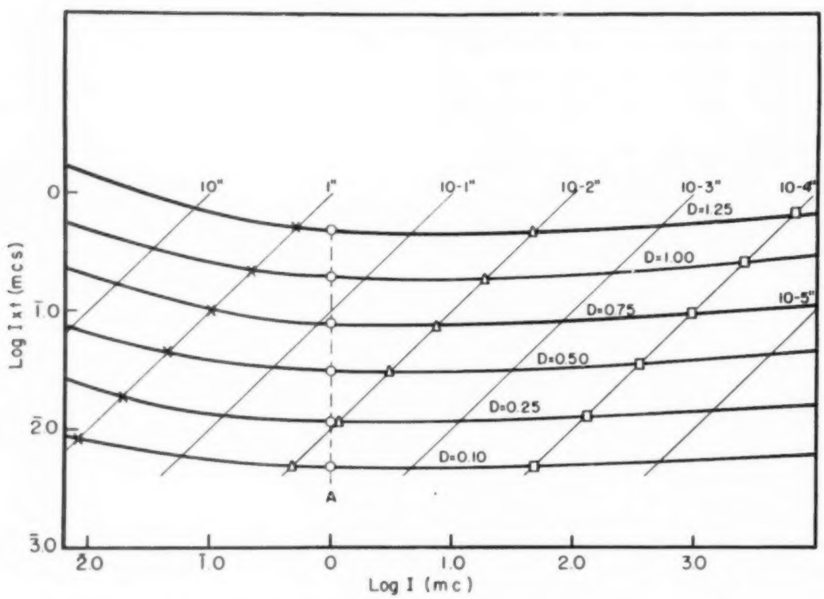

Fig. 2. Reciprocity-law-failure curves based on six levels of density.

to low levels of illumination provides an additional measure of safety in the darkroom. On the other hand, if the material is normally exposed to very low levels of illumination, as in astronomical photography, an emulsion is selected which shows very little low-intensity reciprocity failure. Thus, in different photographic materials, the ratio, A:B, may range from 1.0 to as much as 10. A much smaller range is found in the ratio, C:B, for the various materials, being of the order of 1.5 to 4. There is also an appreciable variation in the optimum intensity with different materials, the value ranging from about 1/10 meter-candle to 10 meter-candles.

If, instead of plotting the reciprocity-failure curve for a single selected value of density, a family of curves is plotted for several density values, considerably more information can be obtained about the effects of this phenomenon on the sensitometric characteristics of photographic materials. Such a curve is shown in Fig. 2. In this figure, the logarithm of the exposure required to produce densities of 0.1, 0.25, 0.5, 0.75, 1.0 and 1.25 is plotted as a function of the logarithm of intensity. For clarity, an expanded scale is used and only part of the intensity range shown in the previous figure is represented. It is seen that these curves are approximately parallel. The vertical displacement of the curves indicates the logarithm of the exposure ratio required to increase the density from the lower to the higher specified density value when the *intensity* of exposure is constant and the *time* of exposure is varied. The log-exposure interval between the intercepts of the 45° lines and the reciprocity curves indicates the logarithm of the factor by which exposure must be increased to increase the density from the lower to the higher indicated value when the *time* of exposure is constant and *intensity* is varied. By plotting the density values of the different curves as a function of the logarithm of the corresponding exposure, characteristic H&D curves can be obtained for any selected value of time and intensity.

Table I. Values of Log Exposure Taken From Curves in Fig. 2.

	Log $I \times t$			
Density	A	B	C	D
0.10	$\bar{3}.68$	$\bar{3}.69$	$\bar{3}.92$	$\bar{3}.70$
0.25	$\bar{2}.07$	$\bar{2}.07$	$\bar{2}.27$	$\bar{2}.08$
0.50	$\bar{2}.49$	$\bar{2}.48$	$\bar{2}.65$	$\bar{2}.56$
0.75	$\bar{2}.89$	$\bar{2}.87$	$\bar{1}.01$	$\bar{2}.98$
1.00	$\bar{1}.29$	$\bar{1}.27$	$\bar{1}.35$	$\bar{1}.43$
1.25	$\bar{1}.69$	$\bar{1}.68$	$\bar{1}.71$	$\bar{1}.83$

Since the vertical displacement of the curves is related to the change in exposure required to produce the indicated density differences at a constant intensity level, exposure time being the variable, the H&D curve derived from utilizing this vertical displacement is, therefore, a "time-scale" curve. For example, it is possible to derive the H&D curve which would be obtained by exposing on an Eastman Type IIb (Time-Scale) Sensitometer. In this sensitometer, the intensity is one meter-candle, shown at A in Fig. 2. The logarithm of the exposures corresponding to the various values of density at this selected value of intensity are shown by the small circles. The actual log exposure values are given in column A of Table I.

To obtain an intensity-scale D-log E curve from the reciprocity-failure diagram, it is necessary to select the log E values at the intercepts of the 45° lines and the reciprocity curves at the various density levels. This procedure is followed because in an intensity-scale exposure the exposure time is constant and the intensity is variable, and in this diagram the 45° lines represent the loci of points of constant time. If it is desired to obtain the intensity-scale curve which results from an exposure time of 0.01 sec, the exposures corresponding to the intercepts of the 45° line at the

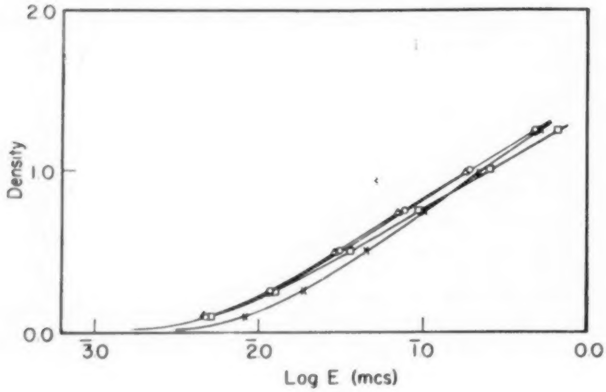

Fig. 3. D-log E curves as follows:
○ = Time-scale at 1.0 mc
△ = Intensity-scale at 0.01 sec
× = Intensity-scale at 1.0 sec
□ = Intensity-scale at 0.0001 sec

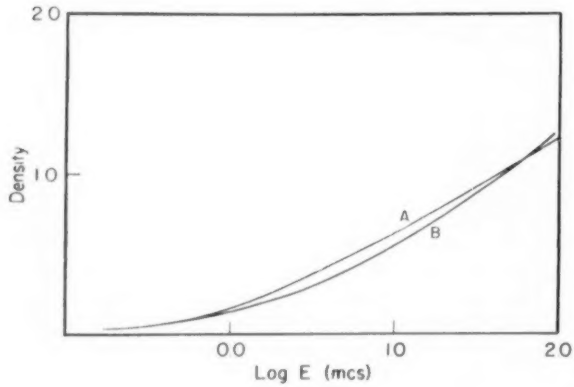

Fig. 4. D-log E curves of Eastman Fine Grain Sound Recording Safety Film.
Curve A = Intensity-scale at 10^{-2} sec
Curve B = Intensity-scale at 10^{-5} sec

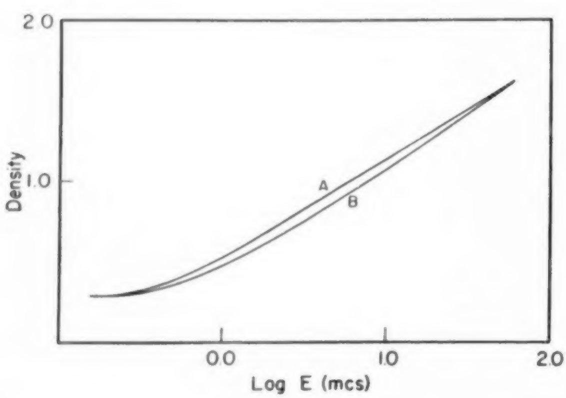

Fig. 5. D-log E curves of Eastman Fine Grain Duplicating Negative Safety Film.
Curve A = Intensity-scale at 10^{-2} sec
Curve B = Intensity-scale at 10^{-5} sec

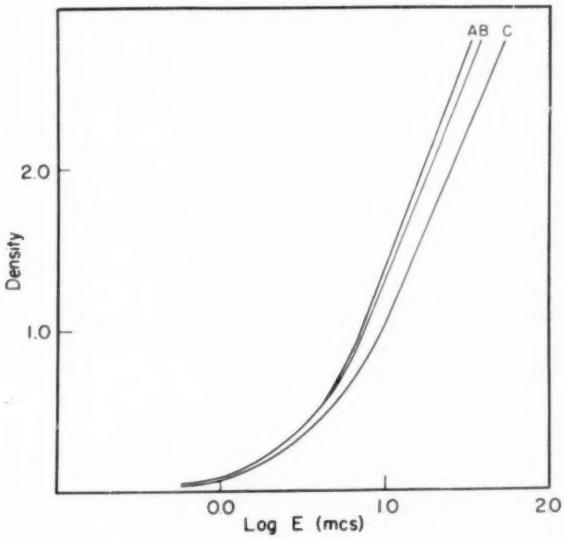

Fig. 6. D-log E curves for Eastman Fine Grain Release Positive Safety Film.
Curve A = Time-scale at 55 mc
Curve B = Intensity-scale at 0.01 sec
Curve C = Intensity-scale at 0.001 sec

0.01-sec position are determined. These values are indicated by the small triangles. The actual log E values are given in column B of Table I. In a similar manner, density-log exposure data can be obtained for an intensity-scale exposure of 1.0 sec (small crosses) and 0.0001 sec (small squares). The numerical values are shown in columns C and D, respectively, of Table I.

Using the data obtained in this manner from the reciprocity-failure curves, the D-log E curves shown in Fig. 3 were plotted. An examination of these curves shows that the sensitometric characteristics of a particular photographic material are dependent, to a considerable extent, upon the intensity and time parameters of the exposure and upon the method of exposure modulation (time scale vs. intensity scale). There is no simple generalization that can be made about the way in which the sensitometric characteristics of different materials change as the time and intensity parameters are altered, although normally the gradient of the D-log E curve decreases as the intensity level increases. Thus, a D-log E curve obtained from a 1-sec exposure (intensity-scale) will have a higher gamma than one exposed at 0.0001-sec (intensity-scale). Other changes occur in the shape of the characteristic curve, notably in the toe region. Generally, the length of the toe increases with increasing intensity. The difference between a time-scale curve and an intensity-scale curve is normally least when the median intensity of the intensity scale is equal to the intensity of the time-scale exposure. Obviously the curves shown in Fig. 3, while typical, precisely characterize only one specific type of photographic material. More or less change in sensitometric curve shape may be expected to parallel larger or smaller failures in the reciprocity law for other films.

An interesting example of a rather large difference of this sort is shown in Fig. 4. These curves are two D-log E curves for Eastman Fine Grain Sound Recording Safety Film intended for use with variable-density sound-recording equipment. Curve A was obtained from an intensity-scale exposure, the exposure time being 0.01 sec. Curve B represents

an intensity-scale exposure, the exposure time being about 10^{-5} sec, which is of the order of exposure times used in sound recording. A large difference in curve shape is apparent, particularly the much longer toe on curve B. It is this characteristic which is realized in actual sound-recording applications that makes this film such an excellent companion for Eastman Fine Grain Release Positive Safety Film.

A smaller difference in D-log E curves is found for Eastman Fine Grain Duplicating Negative Safety Film, as seen in Fig. 5. Here a change from an intensity-scale exposure of 0.01 sec to 10^{-5} sec produces noticeably less difference in curve shape than was shown in Fig. 4.

It has been reported that the change in the characteristic curve of Eastman Fine Grain Release Positive Safety Film when the printer speed is increased is a matter of special interest in motion picture laboratories. In Fig. 6 are shown three D-log E curves. Curve A was obtained with the Eastman Type IIb Sensitometer. The gamma of this curve is 2.6. Curve B, which is an intensity-scale curve based on an exposure of 0.01 sec, is similar to curve A in gamma, but it has a somewhat longer toe portion. Curve C, an intensity-scale curve for an exposure of 0.001 sec, is lower in gamma ($\gamma = 2.4$), and the toe portion is longer than it is in either of the other two curves. This explains why it has been found necessary in practice to alter the IIb "control gamma" in order to maintain constant screen contrast when a major change is made in the printer speed. Changing the "control gamma" is, of course, equivalent to specifying a change in developing time to compensate for the reduction in the gradient of the D-log E curve obtained at the shorter exposure times. Thus, in the example shown in Fig. 6, the development-time increase required to raise the gamma of curve C to 2.6 would raise the gamma of curve A (IIb control gamma) to something over 2.7.

In addition to the differences in the reciprocity-failure characteristics of various photographic emulsions, there are a number of factors which alter the reciprocity failure of any particular emulsion. Of these, those associated with development are of most practical interest. Because of the dependence of the distribution of the latent-image nuclei within the silver halide crystal upon the intensity level of the exposure, the apparent reciprocity-failure characteristics are affected by the choice of developer and the extent of development. By the proper choice of processing it is possible to confine development either to the surface latent image or to the internal latent image. With normal commercial developers, the surface latent image is primarily responsible for the initiation of development, but with prolonged development times the internal latent images may also contribute to the initiation of development. In Fig. 7 is shown a family of reciprocity curves resulting from five different development times in a commercial developer. The curves are based on the exposure required to produce a density of 0.20. It is seen that as development is increased, the high-intensity reciprocity failure diminishes so that, at very long development times, the curve is nearly horizontal at the high-intensity levels. Increasing development time has relatively little effect on the low-intensity reciprocity failure. This effect is explained by the hypothesis that a relatively greater percentage of internal latent images are formed at high intensities than at low intensities and that with prolonged development the internal images become effective in the initiation of development. This suggests the desirability of fully developing films which are used in high-speed photography when maximum sensitivity is required.

Of more than academic interest is the effect of the temperature of the film

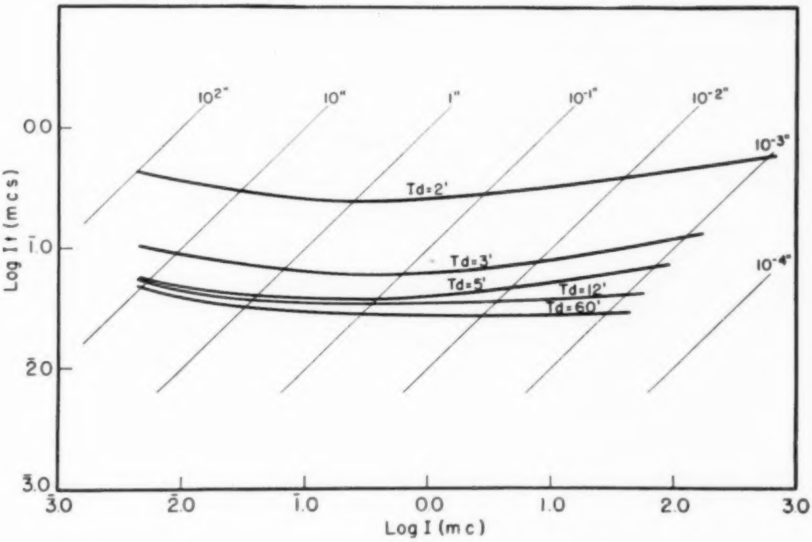

Fig. 7. Reciprocity-law-failure curves for five developing times.

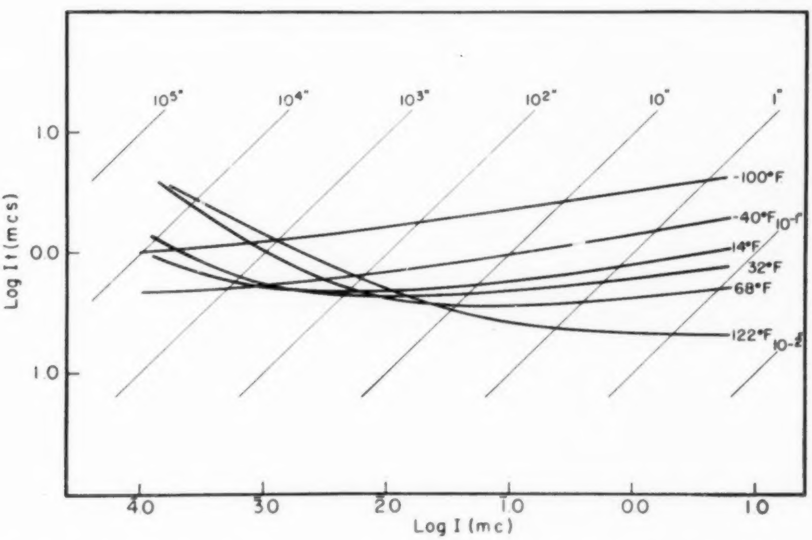

Fig. 8. Reciprocity-law-failure curves showing effect of temperature during exposure.

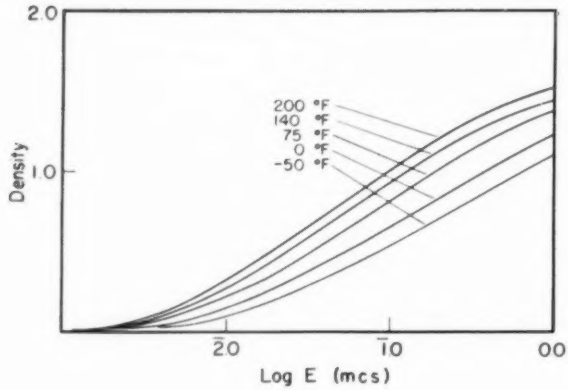

Fig. 9. D-log E curves of Eastman Plus-X Panchromatic Negative Safety Film showing effect of temperature during exposure.

during exposure on the reciprocity-failure characteristics. The group of reciprocity-failure curves in Fig. 8 illustrate the kind of change that takes place when the temperature is varied over a wide range. It is seen that as the temperature is lowered there is a continual increase in the reciprocity failure at high intensities and a decrease at low intensities, which reaches a maximum at about −40 F. At the intensities encountered in motion picture photography, it is apparent that the sensitivity of the film is directly related to its temperature at the time of exposure. Although the range in temperatures shown in this figure is great, it is quite possible that in location work and background photography the temperatures encountered may approach these extremes — perhaps from −40 F to 120 F. In Fig. 9 is shown a family of D-log E curves for Eastman Plus-X Panchromatic Negative Safety Film exposed at 1/100 sec at the temperatures indicated (−50 F to 200 F). It will be noted that in addition to a change in sensitivity, which in this case is greater than a factor of 2, there is also a drop in gamma as temperature is reduced. The magnitude of these changes is fairly typical of negative materials, although with some films, notably infrared-sensitive films, the change in sensitivity is appreciably greater. Over the range of temperatures normally encountered in studio photography, these changes are, of course, negligible.

It is regrettable that it is not possible at this time to present a more comprehensive treatment of reciprocity-law failure at the extremely high intensities which are occasionally encountered in ultra-high-speed photography. This lack of data is a consequence of the very great experimental difficulty of making complete and reliable measurements at exposure times shorter than about 10^{-6} sec. It is expected that suitable apparatus will be available in the near future with which we can extend our knowledge into this region.

Discussion

John H. Waddell (Wollensak Optical Co.): Mr. Tupper, the things that you illustrated in reference to temperature were extremely interesting. However, I don't believe that the temperature range was quite enough. We would like to see from −80 to about +180, the reason there being that at White Sands Proving Ground if you take a camera which is painted black and allow it to stand in the sun from four to six hours, that camera cannot be touched by hand. In the meantime, the film has been cooking all of that time, but it will produce color pictures on Kodachrome at speeds in daylight up to 1000/sec with full exposure, so that the comments you have made on temperature range are extremely

valuable. But we would like to see it extended just a little bit more.

Mr. Tupper: There is some information available for temperatures both higher and lower than those indicated in the graph which showed the effect of temperature on reciprocity-law failure. As the temperature of the film is lowered to very low levels (−300 F) the reciprocity curve flattens out and the sensitivity of the film is very low at all intensities. When the temperature is raised to 200 F the change in reciprocity-law failure follows the same general pattern as shown in the graph, that is, an increase in effective sensitivity at high intensities and a decrease at low intensities. In the case of the color films, the color balance is affected only if the changes in reciprocity-law failure are different for each of the emulsion layers. I believe that the changes follow the same pattern in each of the component emulsions.

Mr. Waddell: I am not particularly worried about color balance at those speeds, because I'm interested in comparative color rather than true color. However, there is one other question that I would like to ask: what is the effect on film speed with variation in temperature? Can one begin to assume that the old chemical rule of doubling of film speed for every 10 degrees rise in centigrade holds generally true or even as an approximation?

Mr. Tupper: I pointed out that the magnitude of the change in sensitivity with temperature depends upon the intensity level at which exposures are made. In the region of optimum intensity the changes in sensitivity with temperature are not very great, but at very high and very low intensities the changes are considerable. However, even at the extremes I expect that a factor-of-two change in sensitivity represents a greater temperature difference than 10 C with normal photographic materials. It is more likely that a change of 20 C or greater is required to produce a factor-of-two change in sensitivity.

Kenneth Shaftan (J. A. Maurer, Inc.): Some time ago Dr. O'Brien's group at Rochester were working on the matter of reciprocity failure and they found some specific information related to dye sensitization. I wonder if you have carried out any further work in that direction?

Mr. Tupper: There has been some work done by J. H. Webb on this problem, but I believe he has as yet nothing definite to report.

Mr. Shaftan: The second question relates to the means or measuring exposure durations shorter than 10^{-5} sec. At 10^{-5} sec there has been a considerable amount of work with regard to sound on film, but what is happening in the realm beyond that?

Mr. Tupper: The only apparatus which is now available for our measurements at very short exposure times was designed and built by J. H. Webb. This apparatus consists of a high-speed rotating drum which carries the film past the projected image of an illuminated narrow slit. We can record to about 10^{-6} sec with fast negative films. The curves which I have just shown were based on exposures made on this apparatus. We are at present considering the design of a sensitometer which will provide exposures at 10^{-7} or possibly 10^{-8} sec.

Brian O'Brien (University of Rochester): Perhaps I can elaborate a little on this reciprocity failure. I think Mr. Tupper knows about the work we have done. For those of you who are interested in practical high-speed photography, as long as you keep to relatively slow speeds — below a million per second — you don't have to worry at any wavelength or any combination to be found. So let me set your minds at ease at once, unless you're going to go to really very high speeds.

The unusual effects we find are limited to exposures less than 1μ/sec and, therefore, to cameras running faster than 1,000,000 frames/sec. Our experiments thus far are limited to exposure times down to 1×10^{-7} sec. At about 10^{-6} sec a new reciprocity failure, not taken into account by the usual Gurney and Mott theory or more recent solid-state modifications of it, occurs for those regions of the spectrum to which a photographic emulsion is dye-sensitized. It does not appear to occur at all for regions in the blue where the natural sensitivity of the silver halide grains is found. Thanks to fine cooperation from the Kodak Research Laboratory which has prepared special emulsions for our use, it has been possible to test this phenomenon to our present experimental limit of 10^{-7} sec of exposure. It is a very interesting problem from the theoretical standpoint, and we hope soon, with a new camera, to reach exposures as short as 10^{-9} sec to further explore this type of reciprocity failure. Let me emphasize, however, that these are very short exposures, and I am speaking of a time range which is quite beyond any ordinary high-speed photography.

A Method of Lighting Large Fields for High-Speed Motion Picture Photography

By HARRY R. CLASON

At the National Advisory Committee for Aeronautics we were confronted, some time ago, with the problem of lighting and photographing at 6000 frames/sec, the path of a missile 6 in. in diameter, traveling for a distance of 30 ft.

Calculations indicated it would require 400 No. 2 photofloods, drawing 1800 amps of current to furnish the 6,000,000 lm required. As this was impractical, we turned to the use of the photoflash bulb.

One No. 11 and one No. 50 fired at the same instant maintained the necessary light, from 15 to 50 msec after the missile's flight. A microswitch installed in the gun's breach, set off the flashbulbs as soon as the missile started moving. The delay in the No. 11 flashbulb was calculated to coincide with the time required for the missile to emerge from the muzzle.

Presented on October 10, 1952, at the Society's Convention at Washington, D.C., by Harry R. Clason, National Advisory Committee for Aeronautics, Langley Field, Va.

We next built a delay circuit to fire flashbulbs with fixed amounts of delay between bulbs. Existing data on flashbulb characteristics indicate that eight No. 31 focal-plane bulbs fired in rapid succession with 55-msec delay between each bulb will give a light variation between 1.15 and 1.45 million lumens, or only 26% variation, for a total duration of 410 msec. This is long enough to expose 60 ft of film at 6000 frames/sec.

The exposure guide number at 6000 frames, with a 64 speed rating film is 16. This means we can take 6000 frames/sec, with lights 4 ft away, at an *f*/stop of 4.

Eight No. 50 flashbulbs fired with 20-msec delay, will give a light variation between 4 and 6.5 million lumens, or 60% variation for a total duration of 150 msec. This is long enough to expose 25 ft of film at 7000 frames/sec.

The exposure guide number for the No. 50 at 7000 frames, with a 64 speed rating film is 32. This means we can take 7000 frames/sec, with the lights 8 ft away, at an *f*/stop of 4.

X-Ray Motion Picture Camera and Printer for 70mm Film

By S. A. WEINBERG, J. S. WATSON, and G. H. RAMSEY

A cinefluorographic motion picture camera and reduction printer using 70mm perforated negative film are described. The camera drive mechanism permits camera speeds up to 15 frames/sec. Prints can be made either on 35mm or 16mm positive film.

THE APPARATUS here described is intended primarily for making x-ray motion pictures[1] on 70mm negative. In this field 70mm film has some obvious advantages over 35mm film. It provides better reproduction of subject detail and is also easier to study frame by frame.[2]

The new 70mm camera (illustrated in Fig. 1 and Fig. 2) was built around an already existing negative film, Eastman Linagraph Ortho 70mm. This film can be obtained perforated to American Standard dimensions, and although the perforations are not specifically intended for use in the motion picture field, we have had no reason so far to regret our choice of the ready-made film. The center-to-center distance between perforations is 0.234 in. The vertical dimension selected for our camera frame is 9 perforations or 2.106 in., less 0.025 in. for the frame line. Frame width is 2.25 in., providing a frame which is more nearly square than the standard motion picture frame and therefore more in line with routine x-ray viewing practice. (See Fig. 3.)

Because of the long travel (more than 2 in.) of the film pulldown mechanism, and also because of the large mass of the 70mm film as compared with perforation size, it seemed advisable to plan for multiple pulldown teeth on each side. The Bell & Howell 35mm speed movement has the special merit of permitting multiple teeth without adding unduly to the weight of the vertically moving parts, and for this reason it was chosen as the model for our 70mm film movement. We found in the end that 6 teeth on each side were necessary. A pilot model of the camera with 5 teeth produced small fracture marks in the perforations, but in the finished camera the addition of an extra tooth on each side provided the remedy.

Presented on October 9, 1952, at the Society's Convention at Washington, D.C., by Sydney Weinberg, Dept. of Radiology, University of Rochester School of Medicine and Dentistry, 260 Crittenden Blvd., Rochester 20, N.Y. This project was supported in part by a research grant from the National Heart Institute of the National Institutes of Health, Public Health Service.

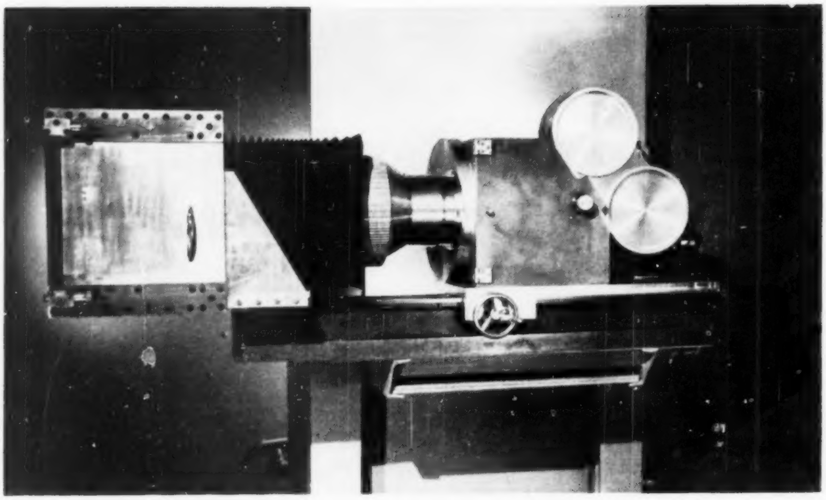

Fig. 1. 70mm camera equipped with 150-mm $f/0.85$ Leitz objective and 400-ft lead-covered film magazine.

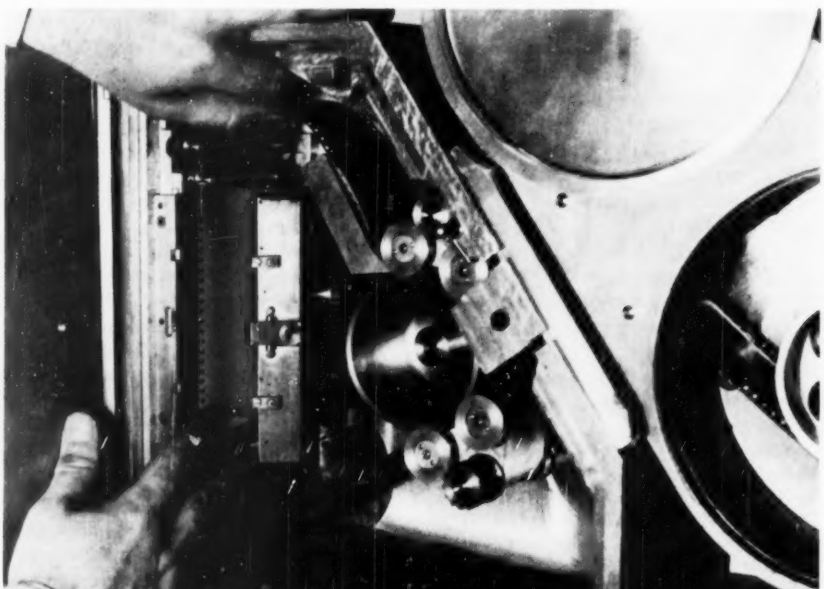

Fig. 2. Inside view of 70mm camera with film gate open.

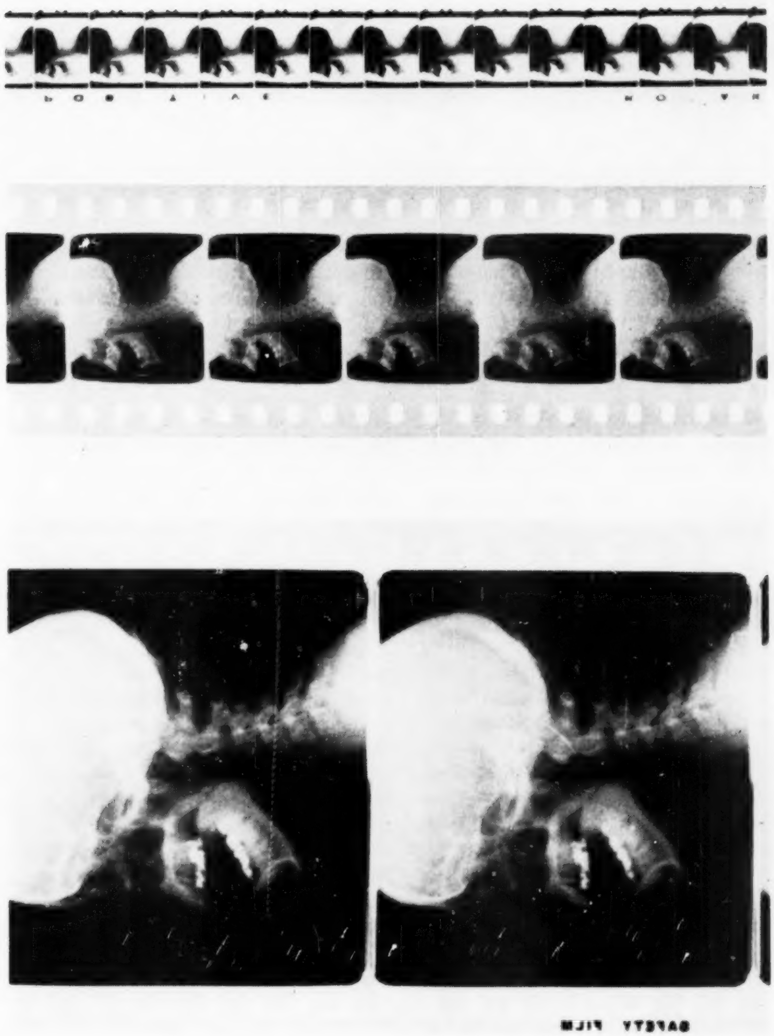

Fig. 3. Comparison of 70mm with 35mm (silent) negative frames. A 16mm print of the 35mm negative is shown at right.

The teeth of the pulldown are spring-loaded and extend into the perforations just enough to give a full bearing surface. During the up-stroke, while the film is stationary, the rounded top edges of the teeth slide over the perforations much in the fashion of a stick over a picket fence. At the start of the down-stroke the squared lower edges of the teeth engage the perforations. The teeth never extend or retract more than 0.007 in.

Pulldown and dwell periods are equal. This ratio is convenient for synchronizing the camera with the 60-cycle pulsed x-ray output. The camera drive is a $\frac{1}{4}$-hp synchronous motor linked to the camera through a gearbox maintaining synchronism through a choice of film speeds of 15, $7\frac{1}{2}$ and $3\frac{3}{4}$ frames/sec. Incorporated in the camera drive is a commutator which triggers an electronic contactor, which in turn interrupts the power supply to the x-ray generator during film transport. This not only spares the patient unnecessary exposure to x-radiation but also extends the time during which the x-ray tube may be energized for any one examination or series of examinations.

In order to minimize vibration the non-moving parts of the camera are of sturdy construction. The "box" without lens, magazine, or motor drive weighs 60 lb. Fully assembled on a rigid lathe bed, and with the fluorescent screen assembly in place, the unit weighs about 250 lb.

It will be remembered that the Bell & Howell speed movement has a flat aperture plate without any curve above or below the aperture, and that the "pressure" plate is also flat and is not pushed by springs or cam action against the back of the film to flatten it, as in other film movements. Tests indicated that 70mm film in a movement of this sort does not in fact lie flat, but bulges centrally into the aperture, sometimes by as much as 0.05 n. This deviation from a flat plane is not constant but varies from frame to frame.

A lens of small aperture might have sufficient depth of focus to take care of the bulging, but considering that desirable lenses for cinefluorography have apertures of $f/0.85$ and more, it is apparent that only a few ten-thousandths of an inch variation will result in out-of-focus areas on the film.

The readily available solution to this problem was to incorporate a compressed air chamber in the camera so that a cushion of air would be formed between the rear element of the lens and the film emulsion, thus flattening the film against the pressure plate. Our intermittent is designed so that the clearance between the aperture plate and the pressure plate is adjustable. This permits varying the air-escape passage to get a satisfactorily uniform flow of air and/or uniform air pressure. Too narrow an escape channel produces a buildup of air pressure which immobilizes the film against the pressure plate, resulting in torn perforations, while too wide a channel permits a fall of pressure and bulging of the film.

From our experience it is evident that a number of air pressure-air escape combinations will permit satisfactory operation. The present separation of aperture from pressure plate is 0.010 in., or 0.004 in. greater than the thickness of the film. The air stream is continuous and is finally vented through a light-tight trap in the body of the camera. Air pressure is about 2 psi. An oil, dust and moisture filter is incorporated in the air line, and a solenoid valve automatically opens the line when the camera is started. A diagram of the air chamber is shown in Fig. 4.

The fact that the film does not come in contact with the aperture plate eliminates scratching of the emulsion, and although fine scratches sometimes appear on the back of the film (despite the high polish of the pressure plate)

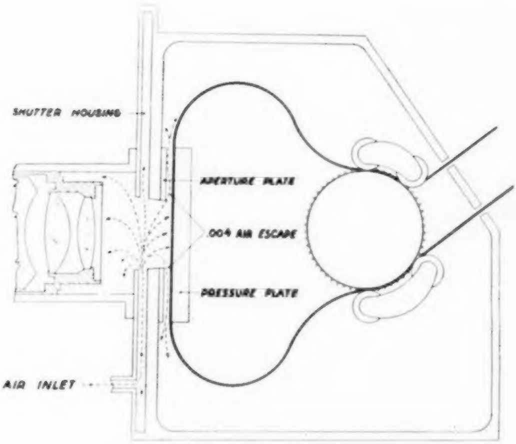

Fig. 4. Schematic of camera showing air-pressure chamber and air-escape passage (exaggerated).

these are so small in relation to the 70mm frame as to be imperceptible on contact or reduction prints made with diffused light. Registration has been good enough so that we have not felt inclined to measure any variations that might be present.

The 70mm Optical Printer

The 70mm printer head is a scaled-up version of a conventional camera movement with spring-loaded pressure plate and side rail, and without separate register pins. The pulldown mechanism has two teeth on each side. There is no doubt that one tooth would be sufficient, but the extra tooth is included as an added assurance of good registration. At the completion of the pulldown stroke the teeth are not withdrawn from the perforations until exposure is completed. Tolerances have been kept extremely close. We theorized that four teeth instead of two would tend to average out possible inequalities between perforations.

Prints for projection are generally made on 16mm fine-grain positive, but sometimes on reversal duplicating film when negative-image prints are desired. Master positives are made on 35mm duplicating positive. Changing from one film size to the other merely involves a change of cameras and of film-to-film and lens-to-film distances. Provision is made for printing at various magnifications and for vertical and horizontal shifts in image position.

The printer turns over at a slow rate (2 frames in 3 sec). This is not inconveniently slow considering the relatively short length of individual cinefluorographic scenes. The projector head and camera (shown in Fig. 5) can be operated separately, in stop motion, through indexing type clutches. Projector or camera can be run forward or backward. They can also be run continuously with automatic printing of two positive frames for each frame of negative. In this way action originally photographed at n frames/sec can be slowed down in the print to $2n$ frames/sec.

Other 70mm Cameras, Past and Present

Probably the earliest 70mm motion picture camera was the Mutograph of

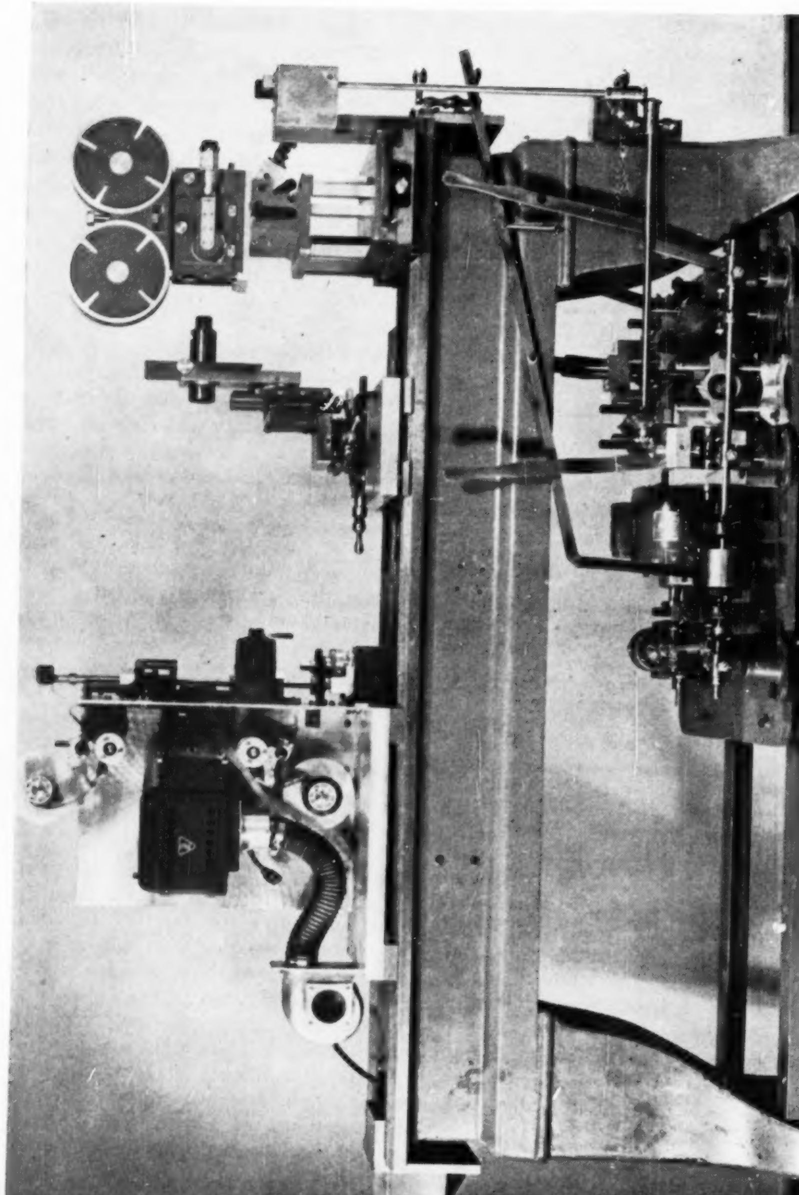

Fig. 5. 70mm printer set up for reduction printing of 70mm negative on 16mm positive film.

Herman Casler (1895), an example of which is on view at George Eastman House. The camera was motor-driven at a speed of 40 frames/sec, had an intermittent of the "broken-roller" type, and used unperforated 70mm roll film, punching two register holes in each frame as it came to rest. The Mutograph negatives were printed on paper for showing in Mutoscope peep-show machines. Another 70mm camera, this time for perforated film, was built by the Lumières. Contact prints from the 70mm negatives were projected on a giant screen (16 × 21 m) at the Paris Exposition of 1900. Nearly 30 years later, during the wide-film craze of 1929, a pair of 70mm cameras was constructed in connection with the Fox "Grandeur Film" project. The Fox camera aperture was of panoramic shape (22.5 × 48 mm) with provision for a 10-mm sound track.[3]

The only contemporary camera comparable with our own is believed to be the 70mm "high-speed sequence camera" manufactured by the Charles A. Hulcher Company of Hampton, Va.[4] At present the Hulcher camera is not adapted to the making of x-ray motion pictures because of its uncertain registration of frames and because of the relative shortness of its dwell period.

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3. Carl Louis Gregory, "The early history of wide films," *Jour. SMPE, 14:* 27, Jan. 1930.
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Discussion

William H. Unger (Elliot, Unger, & Elliot, Inc.): I'd like to know if you relieve the air pressure during the pulldown cycle.

Mr. Weinberg: The air pressure is constant. It is not pulsed. We have a small escape port in the side of the camera. Does that answer your question?

Mr. Unger: Yes. Were the films double-printed on alternate frames to bring them to approximately normal speed or is all the action speeded up? In other words, did you print your negative one frame to one?

Mr. Weinberg: There's a large variation in all these films. I couldn't possibly point them out now. Some of them were 2:1, some 3:1 and some straight prints.

Application of Wide-Angle Optics to Moderately High-Speed Motion Picture Cameras

By H. E. BAUER and A. W. BLAKE

The Douglas Aircraft Co. has gained considerable experience in the application of wide-angle optics to certain motion picture cameras, particularly at 200 to 500 frames/sec. The field of view used ranged from 140 to 160° full-cone angle, and aperture settings of the order of f/1.5 were obtained. Further, the extreme depth of field of the optical system was found to be a very useful feature. Experiences concerning the development of these wide-angle cameras are discussed.

In 1948, the Douglas Aircraft Co. was presented with a very intriguing problem concerning the development of an instrumentation system that could record and thus provide the means of reconstructing the relative approach histories of certain high-speed objects arriving in a somewhat random fashion about an aerial target. A variety of systems besides photography, based on acoustic, radar and other physical principles, were considered; however, for several reasons, many beyond the scope of this paper, it was decided to pursue the development of a photographic system intended to yield film records suitable for eventual photogrammetric analysis. This proved to be a wise decision and the ensuing program was eminently successful.

Presented on October 9, 1952, at the Society's Convention at Washington, D.C., by H. E. Bauer who, with his coauthor, A. W. Blake, is of the Engineering Dept., Douglas Aircraft Co., Inc., Santa Monica, Calif.

Due to reasons of security classification, a further general discussion of the complete photographic instrumentation and its use must be of a limited nature in this paper; however, some of the unclassified components of this system can be revealed. Wide-angle optics as applied to moderately high-speed motion picture cameras will be discussed.

Objectives

An analysis of the overall system requirements brought forth the following general specifications as design objectives for wide-angle motion picture cameras.

(1) Field of view to be at least 142° full-cone angle;

(2) Relative aperture to be near $f/1.5$, allowing an exposure time of the order of one millisecond or less for color film;

(3) Sampling rate to be of the order of 200 to 500 frames/sec;

(4) Visual range for a significant object to be of the order of 250 ft;

(5) Reliable operation and reasonable service life to be achieved;

(6) A means of recording a time base with a time resolution of the order of one millisecond to be provided.

In addition to the above, it was desired that the evaluation of radial measurements of significant images from the film records be accomplished with an accuracy of $\pm \frac{1}{2}°$.

Previous and Concurrent Developments

The initial phase of the program for the development of optical components for the instrumentation system began with a survey of known wide-angle lens assemblies. The results of the survey were not encouraging, for in general the available lens designs proved to be inadequate in several respects. Among the group of "corrected" wide-angle lenses investigated, field angles were usually less than 90° and relative apertures not much better than $f/6.8$. Typical lenses in this category include:

(1) Eastman Ektar, 75°, $f/6.3$;

(2) Bausch & Lomb Metrogon, $85\frac{1}{2}°$, $f/6.8$;

(3) Wollensak Raptar, 84°, $f/6.8$

Although these are all very fine lenses and there are many others, they did not meet the primary objective of a view field of 142° and a large enough aperture to allow millisecond exposure.

The results of investigations into the more extreme wide-angle lenses showed that most of them were inapplicable with respect to available relative aperture. The most extreme wide-angle lens that is corrected for rectilinear rendering is the Goerz Hypergon with a focal length of 60 mm. This lens covers a field of 135° at $f/22$ on a 5×7 in. plate. Another type of lens with similar field coverage is the $f/9$ Goerz Dagor made by Carl Zeiss. Greater coverage is offered with the Robin Hill lens made by Beck of England; it yields 180° at $f/16$. Another very interesting adaptation of the Robin Hill design is made by Zeiss with a fair degree of correction. It has a view field of 210° at $f/6.8$, a focal length of 1.6 cm, and covers a $2\frac{1}{2}$ in. square plate.

Optics

Some very interesting and useful results may be obtained by application of the basic philosophy of the Robin Hill lens design — the placing of a supplementary lens of negative characteristics in front of a positive objective. This is often done when the back focus of a standard wide-angle lens is too short to accommodate extra apparatus in front of the film plane, such as the shutter of a cine camera, the beam-splitting prism in a Technicolor camera, or the rotating prism in a continuous film-flow, high-speed cine camera. The principles involved are shown in a most elementary schematic fashion in Fig. 1. This negative-positive lens arrangement, similar to a reversed telephoto lens system, stimulated considerable interest since the survey of other known lenses had shown little promise.

A brief theoretical appraisal of the desirability of using an uncorrected negative lens was made. It revealed that this type of lens system would offer no benefits to photography other than wide-angle coverage and the use of a high-speed positive lens. The application of standard techniques for complete optical correction to such an arrangement would most likely lead to a long and costly development program with no assurance of successful results. However, it appeared that a few partial corrections could be applied which seemed likely to bring this system within the threshold of acceptable performance for the requirements of the unique instrumentation system being developed. I the negative-positive lens couplet could be readily adapted to the concurrent high-speed motion picture camera development program which had been initiated along with the optical study, then further detailed consideration would be scheduled.

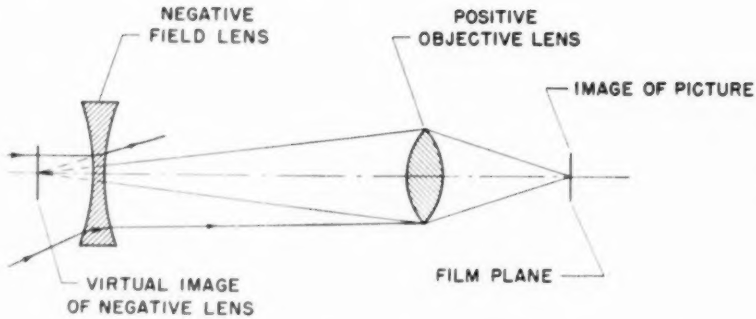


Fig. 1. Wide-angle optical system — schematic.

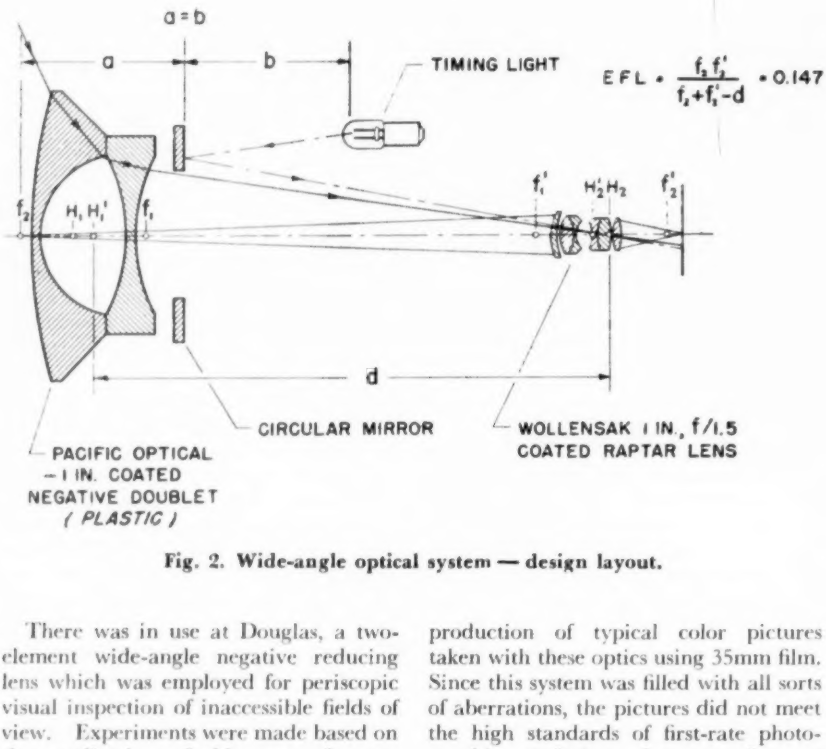


Fig. 2. Wide-angle optical system — design layout.

There was in use at Douglas, a two-element wide-angle negative reducing lens which was employed for periscopic visual inspection of inaccessible fields of view. Experiments were made based on the application of this type of negative scanning lens used in couple with standard camera objective lens and the results were rather impressive. A layout of this optical system is shown in Fig. 2, and Fig. 3 shows a black-and-white reproduction of typical color pictures taken with these optics using 35mm film. Since this system was filled with all sorts of aberrations, the pictures did not meet the high standards of first-rate photographic rendering; however, for our unique requirement, the results were more than adequate. The required field angle was reached; in fact, it was exceeded, as field angles of 160° were readily attained, and the relative aper-

Fig. 3. Typical pictures taken with wide-angle optics, using color film in 35mm camera; this is an aerial view of a desert village from an altitude of 2500 ft true, with camera rolled 22° and pitched down 13°.

ture was found to be slightly less than that available from the camera objective lens. Thus, a relative aperture close to $f/1.5$ was realized.

The question may here arise as to how it is possible to obtain a picture that has any degree of sharpness from an optical design which has no apparent correction. It should first be recalled that the optical design is intended for a very singular application. When faced with the need of a high-speed extremely wide-angle lens system, some desiderata had to be given up. Even a brief perusal of the design under discussion will reveal defects of astigmatism and curvature of field as well as distortion. Distortion can be calibrated and a requirement of true rectilinear propagation can thus be circumvented. To account for astigmatism, and curvature of field, a convergent lens would have to be introduced into the field-lens elements, but such an addition would cut down the extremely wide angle and the speed. Actually, curvature of field is minimized by the extreme depth of field of this very short 0.147-in. focal length system; objects practically

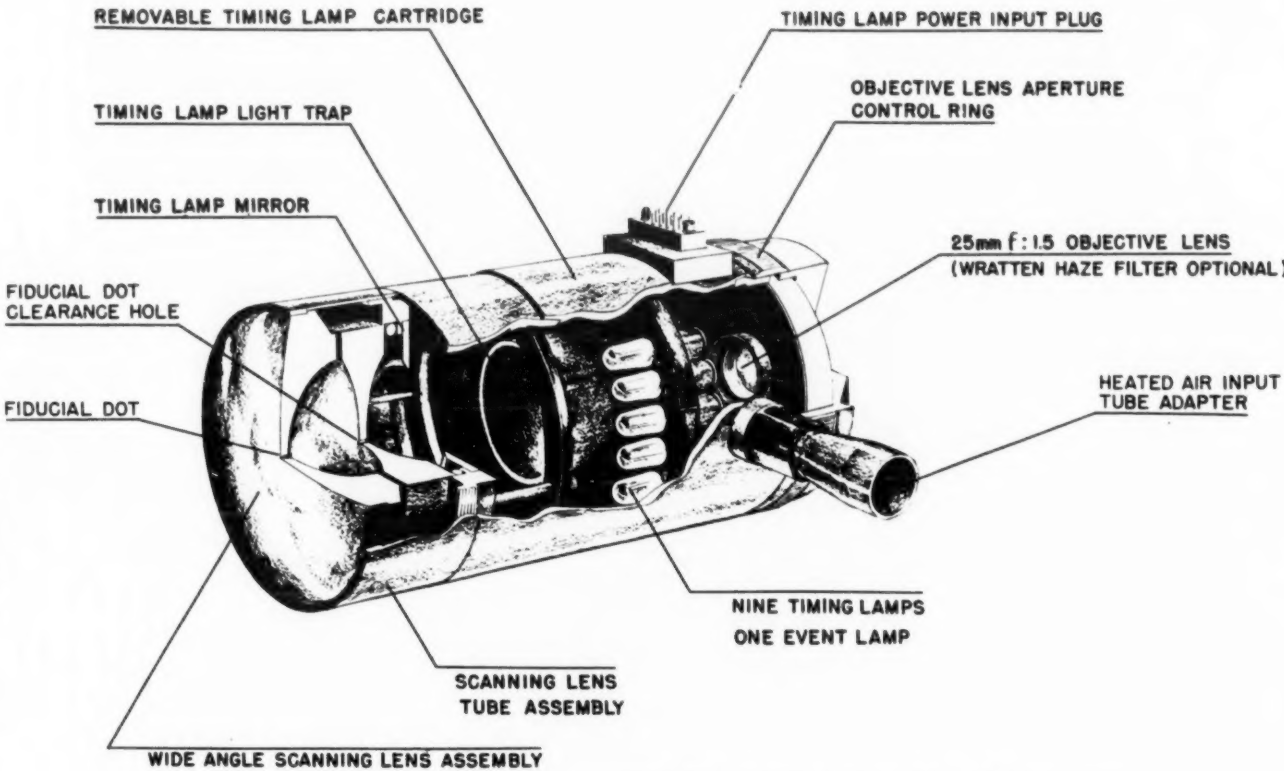


Fig. 4. Scoring camera wide-angle optical assembly; field of view in excess of 142° full-cone angle.

in contact with the front lens element are in sharp focus, as are objects at extreme range. Although not corrected for curvature of field, the effects are considerably reduced by this great depth of field. The caustic image surface produced by astigmatism remains as the major detrimental factor in the system, and this effect is only partially minimized by the depth of field. In order to maintain the aperture rating $f/1.5$, with the 142° field coverage, allowances will have to be made for the unavoidable residual aberrations encountered in extremely wide-angle optics.

Wide-Angle Optical Assembly

The optical assembly which converts a motion picture camera into a wide-angle (142° full-cone angle) camera, with provision for time correlation and suitable for photogrammetric application, has the following components:

(1) A conventional cine objective lens of high relative aperture;

(2) An external means of adjusting the objective lens diaphragm;

(3) A supplementary negative field lens;

(4) A lamp cartridge repeater clock containing a battery of 10 timing lights;

(5) An annular mirror to reflect the timing lights in proper focus onto the marginal section of the film frame;

(6) Provisions for protecting the optical system against fogging or icing;

(7) A fiducial mark on the field lens within the focus range of the objective lens.

Design considerations of such a wide-angle optical assembly, in which the camera objective lens is focused on the virtual image of a negative field lens, are based on three fundamental variables: effective focal length of the negative lens, effective focal length of the positive lens, and the separation of the two lenses. The combined focal length of the assembly is a function of the above variables and many combinations of these were studied and tested. Considerations of field coverage, magnification, component packaging and quality control led to a production design shown in cutaway form in Fig. 4. For use with 16mm motion picture cameras, a 25-mm $f/1.5$ Wollensak Raptar objective was chosen, while for 35mm cameras, a 50-mm $f/1.5$ Wollensak Raptar Dumont objective was used.

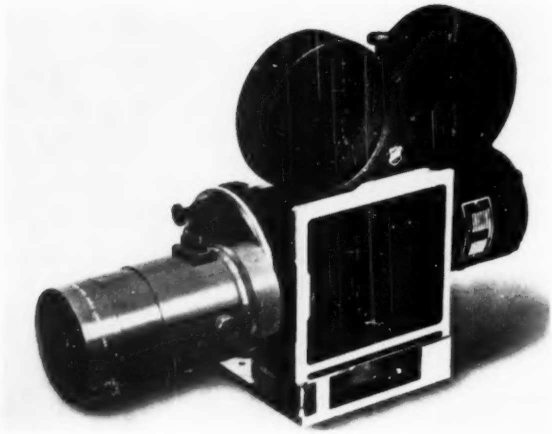
The negative doublet is a −25-mm focal length plastic lens; it will be discussed in detail later. The lens separation is 6.80 in. for 16mm cameras and 7.37 in. for 35mm cameras. Thus, for 16mm film, an 0.30-in. diameter circular image (representing a usable 142° field cone angle) is registered while a 0.75-in. diameter image (representing 152°) results when a 35mm film is used. In either case, sequential images on the film are tangent to each other to utilize maximum magnification.

Although most experimental versions of this wide-angle optical assembly were designed and developed by Douglas engineers, the production articles as shown in Figs. 4 and 5 are the result of a joint design effort by Douglas and Wollensak engineers. The production lens assemblies are now manufactured by the Wollensak Optical Co. in compliance with Douglas specification drawings.

The plastic lens is manufactured by the Pacific Optical Co. of California and the degree to which quality control has been attained is an achievement in itself.

Plastic Wide-Angle Reducing Field Lens

The machined and polished negative field lens used with considerable success in this wide-angle package is made from Plexiglas which has an index of refraction of 1.49 for the sodium D lines. The front 4-in. diameter element is convex-concave and the rear 3-in. diameter element is bi-concave. The lens design incorporates no built-in aperture stop but there is a measurable entrance pupil of 1.06 in. in diameter and an exit pupil of 1.82 in. in diameter. The mean focal



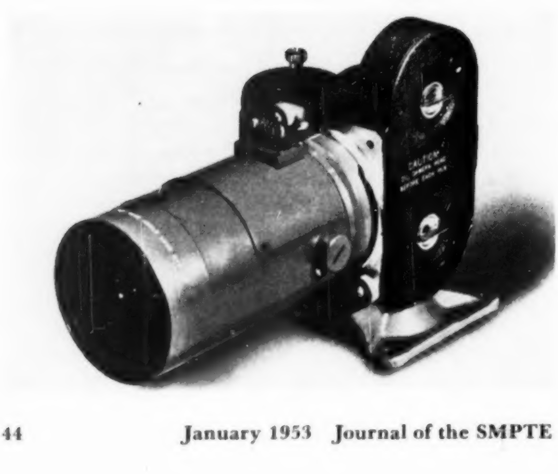


Fig. 5. Production wide-angle optical assemblies applied to high-speed cine cameras: top, 35mm Bell & Howell Ultra-Speed; middle, 16-mm Wollensak Fastax; bottom, 16mm Bell & Howell Filmo.

length is a minus one inch for this combination.

Even though there are no designed corrections made for the aberrations in this field lens, there are some compensations (a number of which have already been discussed) that can be designed into the complete lens assembly to minimize the effect of these aberrations.

To increase light transmission by reducing reflections, the plastic lens was given a standard coating with a fluoride compound. This coating also diminished the surface light-scattering effect (haze) prevalent in plastics, which along with reflections, tends to cut down picture contrast. The baking process used to harden the coating on glass lenses cannot, of course, be used with plastics, yet the unbaked coating has been found to be quite durable.

Glass Wide-Angle Reducing Field Lens

In an effort to explore the possibilities of improving resistivity against abrasion and, possibly, also the optical properties, a version of the negative doublet was designed and made of glass. The exterior dimensions were essentially the same as those of the plastic lens.

Studies of the inherent qualities of the glass doublet in comparison with its plastic counterpart were made. It appears that some advantage may be gained from the use of the glass lens with respect to light-scattering and crazing, but any benefits in resolving power failed to show up in tests. Pictures taken with a glass wide-angle optical assembly compared to those taken with a plastic assembly show little, if any, improvement. The small advantages of the glass lens are outweighed by the relative cost of the article when compared with the end product.

Time-Correlation and Repeater Clocks

One of the objectives of the program was to develop a means of referring the camera's film record to a common time base with a time resolution of the order of one millisecond. This was desirable for several reasons, most of which are beyond the scope of this presentation. However, one important reason was to provide a means of correlating time between two or more cameras recording the same event, thus avoiding the need for a costly exposure synchronization system.

This objective was met by the development of an Electronic Master Time Clock (syncopic binary time code generator) which provides accurately timed electrical pulses eventually to be presented to the view field of all related cameras in the form of an array of flashing neon lamps called Repeater Clocks. The resultant images on the film records form a unique syncopic binary code, so constructed that only one digit changes at any step, thus avoiding misinterpretation when carry-over, or "double" exposure, occurs during a camera exposure cycle.

Cameras

Although this paper deals primarily with the development of a wide-angle optical system of large relative aperture, it may be of interest to mention another development program that was initiated concurrently concerning the selection of motion picture cameras in the speed range of 200 to 500 frames/sec intended to use these wide-angle optics when developed.

In formulating the design philosophy guiding the development of suitable types of motion picture cameras into wide-angle moderately high-speed cameras, suitable visual range, sampling rate, reliable field operation and reasonable service life were considered. Studies were made comparing the relative merits of moderately high-speed 16mm cameras, as well as 35mm models. The results of the studies led to the selection of the Wollensak Fastax and the Bell & Howell Filmo cameras as two types suitable for development. In the 35mm field, only the Bell & Howell Ultra-Speed was considered suitable. These

cameras, shown in Fig. 5, illustrate the production lens assembly using the plastic field lens.

The Fastax camera was modified for best operation in the 400- to 500-frames/sec range. It may be of some interest here to note that it was a slight task to slow the camera down for reliable operation at these relatively low speeds.

In the field of 16mm intermittent motion picture cameras, the survey of available types led to laboratory tests with the GSAP (Gun Sight Aiming Point) and the Bell & Howell Filmo Model 70. The well-known family of GSAP cameras was found to be easily modified to accept wide-angle optics of 160° full-cone angle, and satisfactory performance was experienced when the cameras were run at 64 frames/sec, which is within their design limitations. However, attempts to "hop up" the GSAP to yield reliable frame rates up to 200 frames/sec were soon terminated. Although limited operation at these excessive frame rates was occasionally attained, the camera then became so unreliable that success with future developments seemed very unlikely. Laboratory tests with the Filmo yielded results with frame rates up to 230 frames/sec and best reliability in the 180- to 200-frames/sec range.

It was through the cooperative efforts of Training Aids Inc. (special California representative of the Bell & Howell Co. of Chicago), the Bell & Howell Co., and Douglas engineers that the Model 70 Filmo was modified for reliable operation at 200 frames/sec and adapted to accept the same standard wide-angle optical assembly used on the Fastax Camera. Its photographic performance surpassed expectations and is matched only by the Ultra-Speed camera in visual range and photographic sharpness.

In the realm of 35mm intermittent motion picture cameras, the Bell & Howell Ultra-Speed was an obvious choice, for it had already been developed as a 200-frames/sec camera. Later in the program, it was modified to meet the system's requirements. The modification task here was simply that of attaching a wide-angle optical package.

Film

It became apparent in the early phases of the development program that pictures taken with color film were far more satisfactory than with black-and-white. The optical system under discussion presents some difficulties with chromatic differences of magnification. This situation becomes more critical at the edge of the field of view; however, a more distinct image is apparent on color film such as Kodachrome because there are three different color-sensitive layers to register monochromatic separate images. The resultant fringing actually produces a colorful outline that is considerably easier to distinguish than the fuzzy grayed outlines produced on black-and-white film.

In an attempt to improve the quality of film records, experiments were made with filters so as to produce, in a sense, more monochromatic light. Test results using filters with black-and-white film were not very promising; however, results from using filters with Kodachrome film were more gratifying.

Daylight, Type "A," and Commercial Kodachrome films were tried with suitable filters. Daylight and Type "A" being inherently more contrasty than the commercial emulsion were found to give a higher overall resolving power, since resolving power increases with contrast. As previously discussed, the more monochromatic the registering light, the better the film records. With this in mind, tests were made to compare Type "A" used with its compensating filter, and Kodachrome Daylight film used with a normal haze filter. It appears from tests that the compensating filter for the Type "A" film, being heavier (absorbing more light at the blue portion of the spectrum) than the haze filter for

the Daylight film, does yield some slight advantage.

Resolving Power

As expected, this optical system suffers from astigmatism. This effect is noticed in resolving power tests in an interesting manner. In the paraxial region, maximum resolving power of Kodachrome is almost obtained. Radial resolving power drops off very little from the center to the picture edge, while tangential resolving power drops off at a much greater rate.

Conclusions

The development program, guided by the broad design objectives previously discussed, was successful in producing several versions of moderately high-speed motion picture cameras equipped with wide-angle optics.

The wide-angle optical system as developed during this project yields excellent results for the purpose intended. These results were achieved by a careful program of minimization of the system's optical deficiencies and exploitation of its capabilities.

In practice, the photogrammetric analysis of camera film records was readily accomplished to the degree of accuracy desired, and the photographic instrumentation system has been proven as a field service facility developed well beyond the laboratory and experimental stage.

Discussion

John E. Voorhees (*Battelle Memorial Institute*): What was the final *f*-number of this combined lens system?

Mr. Bauer: We feel that the aperture value of the system is slightly less than that of the objective lens used. With the present *f*/1.5 objective, the practical aperture value of the system is about *f*/1.7.

Mr. Voorhees: Wasn't the focal length changed?

Mr. Bauer: Yes. The objective lens is racked forward to focus on the virtual image of the field lens. In order to bring the system to focus at infinity, the objective is set at a focal length of near 28½ mm resulting in system focal length of about 3¾ mm.

William E. Cowles (*General Electric Co.*): Have you tried projecting the film records obtained from the optical system onto a hemispherical screen?

Mr. Bauer: We have done a very limited amount of work using that technique. At one time, it was considered as a possible aid for photogrammetric analysis of the film records. However, suitable techniques for data reduction of the film records have now been established as routine, using normal flat projection devices, such as the Eastman Recordak or our own Douglas Iconolog film reader.

Mr. Cowles: That projection technique has been tried with another type of lens. I don't know if the characteristics of that lens and yours are the same.

Mr. Bauer: I believe you may be referring to the Jam Handy lens. At one time I had an opportunity to look at photographs of the assembled lens. Unfortunately, pertinent schematics, reports, etc., were not available for study; therefore I cannot compare the characteristics of that lens and the lens system described in this paper.

E. P. Martz, Jr. (*Holloman Air Force Base*): You note that experiments were made with filters. Does the use of filters reduce the advantage of using color film?

Mr. Bauer: No. Lateral chromatism in this system is, of course, very apparent when using either color or black-and-white film. With color film, this effect works to our benefit; with black-and-white film, the effect is very much a disadvantage. For example, consider a narrow, white post near the extreme edge of the field. On color film, this post will be beautifully fringed in colors and readily detected due to the color contrast. However, on black-and-white film, the white post will definitely be obscured in the fuzzy gray images resulting from chromatic differences of magnification.

Mr. Martz: The color filters you used — were they monochromatic?

Mr. Bauer: No. We used a Wratten 2B with Daylight Kodachrome, and Wratten No. 85 with Type A. The purpose of these

filters is to take advantage of the principle of using slightly less chromatic light while retaining color contrast. For our present work, this contrast is desirable.

Mr. Martz: Have you made resolving power tests? If so, what order of magnitude of resolution, in lines per millimeter, resulted?

Mr. Bauer: We have made tests using Kodachrome film which has a resolving power of close to 60 lines per millimeter. The tests were conducted under conditions as near ideal as practical with a test set-up. Under these controlled conditions, near maximum resolution was obtained in the paraxial region. However, due to astigmatism and lateral chromatism, tangential resolving power dropped off to about 15 and radial resolving power to approximately 40 lines per millimeter at the extreme edge of the field.

Anon: Would you care to make some comments on plastics for wide-aperture optics?

Mr. Bauer: I can only give you information pertaining to our particular field. There is a very limited choice in index of refraction for optical plastics. Plexiglas is about 1.49. Should we attempt any corrections of the field lens, some glass will have to be used. For our present uncorrected field lens, we would realize only a few benefits from a glass version. Fluoride coatings on glass can be made more durable by baking, crazing would be eliminated, and the surface light scattering effect [haze] would be reduced. All of these factors were considered but the relatively low costs of plastic optics were very attractive. We have had some trouble with plastic crazing at high altitudes; however, it has not seriously interfered with our work.

Winston O. Johnson (E. I. du Pont de Nemours & Co.): Does the haze problem apply when you have a fluoride coating?

Mr. Bauer: We believe that the haze problem is reduced by coating, but the benefit provided by a fluoride coating is an increase in light transmission. At the present time, the coating cannot be baked on and is therefore soft, requiring extra care in handling.

Anon: Can these lenses be used for short distances?

Mr. Bauer: If the extreme depth of field does not encompass close objects when focused at infinity, this system can be focused to shorter ranges.

Anon: What I am thinking of is a test chamber which is no more than 10 feet across. We would like to see everything in that chamber in focus.

Mr. Bauer: I believe that the extreme depth of field of this system might be used to your advantage.

Anon: Is it available commercially?

Mr. Bauer: Yes. Wollensak Optical Company or Douglas Aircraft Company can supply the necessary equipment.

B. J. Brettler (Edgerton, Germeshausen & Grier): I wonder if you would comment a little on distortion calibration.

Mr. Bauer: We place an array of targets, ten degrees apart, in a semicircle of 30-foot radius. Over the center of the circle is placed the node of admission of the optical system. With the targets and cameras carefully located, pictures are taken, and a distortion curve is determined from measurements made on the picture. Many of our optical systems were checked this way. We found that there was only a very slight difference between lenses; therefore, a standard distortion curve could be made. The optics of all the different types of cameras used were also rotated about the optical axis, and here again, the differences were negligible. From the distortion curves determined from the film records, we made an overlay grid to be used on a Recordak viewer or our own Iconolog. With this system, we are reading film records to well within plus or minus a degree, up to 50 degrees off axis.

New Automatic Film-Threading Motion Picture Camera

By G. J. BADGLEY and W. R. FRASER

The new automatic film-threading motion picture camera designed and built by G. J. Badgley at the Naval Photographic Center provides: (1) a 16mm motion picture camera that can be easily loaded, quickly threaded and operated under adverse conditions normally encountered by naval photographers; and (2) a motion picture camera that can be used for recording of radar and television images appearing upon cathode-ray tubes.

THE modern professional motion picture camera is a marvel of engineering design and construction. Without tolerances that are, in some instances, measured in ten thousandths of an inch, it would not be possible to achieve the high degree of technical perfection in cinematography that we know today. A "must," and rightfully so, has been "rock-steady" motion pictures with accompanying near-perfect registration. The loading and threading of film in such a camera, however, have been secondary in importance and considered to be necessary evils that could be minimized by employment of skilled and experienced motion picture cameramen.

Such a solution, however, is not so easy where the Armed Forces are concerned. A Navy Photographer, for example, may not touch a motion picture camera for days, weeks or even months at a time. He must be a "Jack of all trades." One day he may be an aerial photographer, another, a processing man, a still photographer, a color man or any one of a dozen or more occupations falling under the general heading of "Naval Photographer." Being unable to concentrate on any one field of photography, let alone on any one motion picture camera, he is interested primarily in a camera that is easy to load and operate under a great variety of conditions. Rarely will photography be conducted under the ideal conditions found on a sound stage; more likely the scene will be "shot" under enemy fire, in an aircraft or on board a ship at sea. Throw in the weather element — both hot and cold — and it becomes painfully apparent that our navy cinematographer has a few things on his mind other than his camera.

It is well known that the amount of footage exposed varies inversely with the

Presented on October 19, 1951, at the Society's Convention at Hollywood, by G. J. Badgley, who read the paper, and W. R. Fraser, Research and Development Dept., U.S. Naval Photographic Center, Naval Air Sta., Anacostia 20, Washington, D.C.

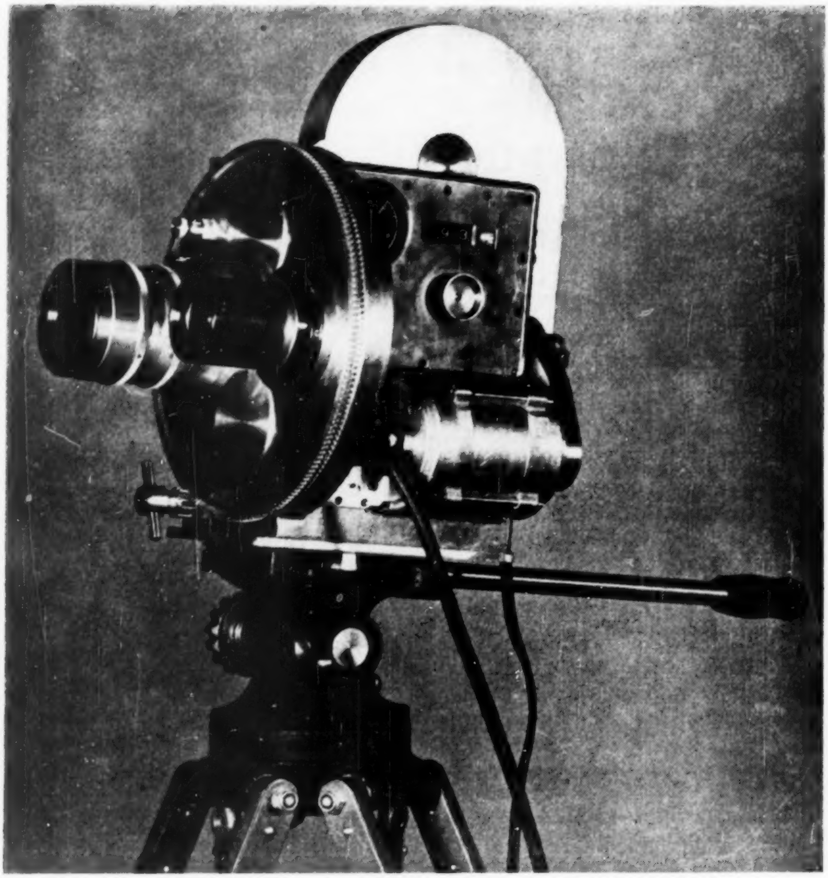


Fig. 1. A general view of the Badgley "Automatic Threading" motion picture camera. The 25-mm *f*/0.7 Polaroid and 55-mm Bausch & Lomb high-speed lenses, turret locking ring, camera drive motor, and 400-ft film magazine are in position.

difficulties encountered, and consequently it is important to insure that the camera is not another offender. Invariably, when environmental difficulties are encountered, the second roll of film remains unexposed. The reason, obviously enough, is due generally to the laborious procedure required to thread the film in the camera. With this in mind, it was decided to attempt development of a motion picture camera that would have an automatic threading feature, be usable in all kinds of weather by relatively untrained personnel and be practically foolproof in operation.

From a study of both past and present cameras, it was found that while numerous improvements have been made in the camera body proper, very few effective improvements have been made in the magazine or film carrier. Some attempts have been undertaken to minimize the difficulties encountered in putting film into a camera and in shortening

the time factor of threading and setting the loops. For instance, a series of cameras has been developed in which a large part of the camera mechanism — the pulldown claws, the aperture and the film gate — is incorporated in the magazine or film box. This method, however, results in an overly expensive magazine of which there must be several for each camera. Also, the fitting of these magazines to the camera requires a high order of precision which *cannot* be retained during the normal life of the camera due to wear and tear incident to service use.

Other cameras developed were limited to magazines with a film capacity of 50 to 100 ft with the necessary loops and sprockets incorporated within the magazine. However, this system was accompanied by troubles arising from installation of the necessary couplings and drives within the main body of the camera. Another system utilized feed sprockets incorporated within the magazines, but the accumulation of dust and dirt that could not be removed without completely dismantling the assembly was a source of trouble. In general, these camera types left a great deal to be desired in reliability, simplicity and ease of operation and maintenance. In summation, the problem was reduced to the following:

1. To design and develop an automatic threading camera wherein the film will be threaded during the process of attaching the magazine to the camera. This also included the requirement that loaded magazines could be removed from the camera at a moment's notice and then re-used in the camera at any time thereafter; and

2. To divorce all moving mechanisms (except the feed and reroll spindles) and their accompanying drives from the film box or magazine.

The Experimental Model 16mm Camera

In the process of developing a camera that would comply with the aforementioned performance requirements, a 16mm experimental model camera was designed, built and tested (Fig. 1). The camera weighs 15 lb and has been used as the vehicle to prove the feasibility and practicability of the numerous features that it incorporates. As indicated by the title of this paper, the major feature permits automatic threading of the camera regardless of the film capacity of the magazine. Other features include unique magazine light-traps, high-speed film pulldown movement for television and radar scope recording, a special stabilized shutter to minimize "shutter bar," constant-speed main drive shaft to insure smoother camera operation, turret locking ring as an antivibration measure, quickly removable electrical assemblies, and special features to facilitate television and radar scope recording.

By selecting certain features of the experimental camera, it will be possible to develop special-purpose cameras including: (1) a combat version, also suitable as an amateur camera; (2) a radar and/or television recording camera that is portable and suitable for use in aircraft; and (3) professional versions, both 16mm and 35mm with reverse take-up and other refinements.

In designing the camera, precision workmanship has been used where necessary. However, precisely fitting parts have been avoided where not required, as experience has shown that unnecessarily snug fits are detrimental — especially under extreme high- and low-temperature conditions and also in the presence of fine particles of dust or sand. In addition, all precisely related parts, wherever possible, have been constructed as integral units. Provision has been made to permit simple adjustments of moving parts that are subject to normal wear.

Magazine

The principal feature of the camera is automatic threading regardless of the film capacity of the magazine. During the act of attaching the loaded magazine to

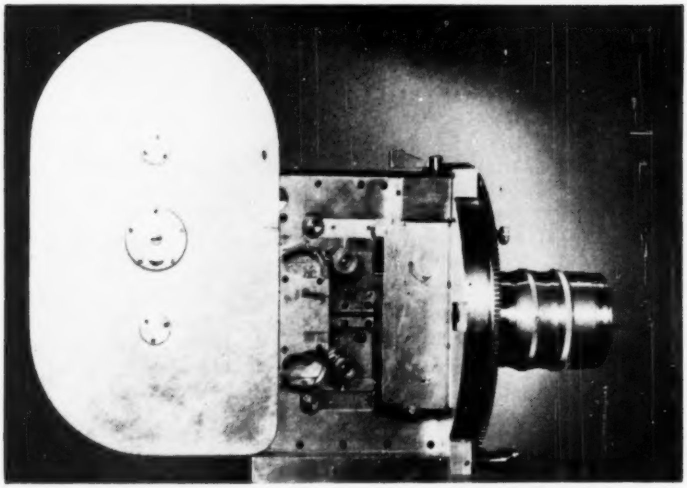


Fig. 2. View showing position of the 400-ft film magazine just prior to engagement of film by sprockets.

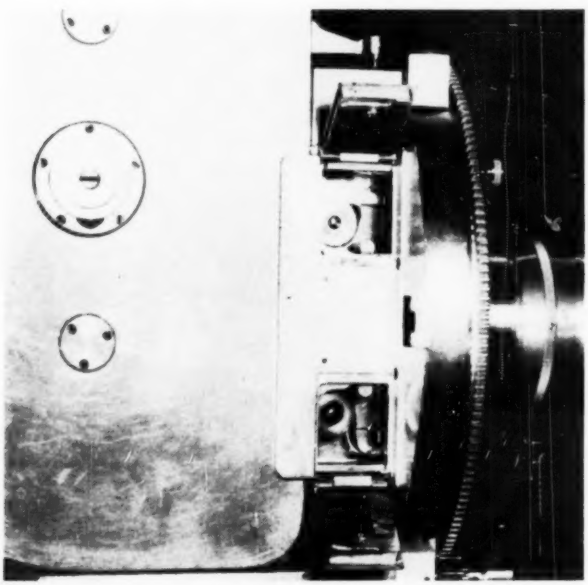


Fig. 3. View of magazine seated in final locked position. Note film loops formed during process of "pushing" magazine forward into position.

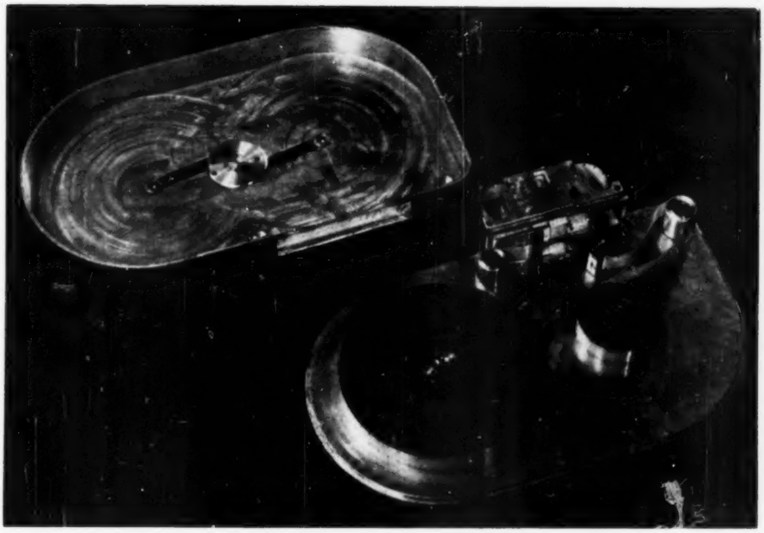


Fig. 4. Internal view of 400-ft film magazine. The "nose piece," which contains the light-traps, is the heart of the magazine and it can be used in similar film magazines ranging from a capacity of 50 ft to 2000 ft or more. Note cover locking mechanism in lid.

the camera, the two camera film sprockets are caused to move forward and also to rotate in such a manner that the sprocket teeth engage the film perforations. As a result, two film loops of optimum length are always formed. The magazine becomes locked in position at the end of the throw, the entire operation requiring less than two seconds. Figure 2 shows the magazine attached to the camera prior to being pushed forward while Fig. 3 shows the magazine locked in the final position. By means of this simple procedure, the magazine-changing problem is greatly reduced and the cameraman, although forced to use heavy gloves during cold weather conditions, will have a much better chance to complete his photographic assignment.

In the conventional-type film magazine, the sides and base comprise the major part with the cover or lid being a circular, threaded plate. In the experimental magazine, however, the sides are part of the cover, thus leaving a clear, flat plate with film spindles and guide rollers (Fig. 4). This feature facilitates loading since there are no sides to interfere with placement of the film on the spindles. The cover lock supports the free end of the film spindles, thereby providing additional mechanical support to these members. The cover slips on over the base plate and may be positively secured in position by a simple one-twist operation.

Loading of the magazine has been simplified by the design of unique light-traps that are symmetrical and interchangeable and which may be readily disassembled for cleaning and then reassembled — all without the use of tools. These light-traps have been so designed that the film during loading in the magazine must follow the only path available through the light-traps.

One pair of side guides for the film aperture is in the camera and is fixed relative to the pulldown pins. The other pair, which is in the magazine, is mov-

able and spring-loaded. However, the operating spring for this movable pair in the magazine is in the camera and does not close the guide on the film until the magazine is fully seated and the back pressure plate has seated the film against the aperture plate.

Design of the magazine reverse take-up is unusual in that a nonrachet-type take-up that completely disengages the feed-roll spindle is employed. Operation is dictated by the direction of rotation of the driving gears which couple or uncouple with the particular film spindle concerned.

High-Speed Pulldown

Besides automatic loading, the major innovations in this camera have been dictated by the high degree of precision required for television recording. This camera has a high-speed pulldown movement which permits use of the 288° shutter opening for kinerecording at 24 frames/sec. An ample safety margin of operating coverage by the shutter during movement of the film is provided since there is approximately a 10° shutter coverage both before and after exposure.

Stabilized Shutter

One of the major problems in the construction of a television recording camera is the design of a shutter movement that is completely free of backlash. This was accomplished by tying all related parts to a common shaft; that is, the advance cam, motor drive and shutter are all on the main shaft. There are no loose couplings that can produce objectionable backlash.

In order to achieve further stability, a weighted flywheel rim is loosely mounted around the periphery of the shutter member and runs between the pole pieces of a magnet. In this way the mechanical dampening action of the slipping flywheel and the electrical drag or braking action of the hysteresis current generated in the shutter rim are both utilized.

Constant-Speed Main Drive Shaft

The main drive shaft of the camera rotates at a constant speed at all times during the entire cycle of operation. This is in contrast to several motion picture cameras that utilize an acceleration mechanism to speed up the pulldown cam during the film-transfer portion of the cycle, with a corresponding slow-down of the pulldown cam during the exposure portion of the cycle. This intermittent velocity is not conducive to steady shutter travel, and as a result the shutter must be driven by other means such as a separate synchronous motor, for example. This method, however, means added weight and the mounting of the motor precludes the use of turret lenses. The added weight, interlocking mechanisms and extra wiring all detract from portability which is so important in airborne operations.

Turret Locking Ring

When cameras are used in reciprocating engine type aircraft, a certain amount of vibration will be transmitted to the camera and as a result local vibrations may be generated between the various parts of the camera. These vibrations may be of sufficient severity to affect the photographic image, and to prevent this, use is made of a large threaded ring that may be screwed up against the outer periphery of the turret. This ring, which resembles the ring gear of an automobile flywheel, is rotated by a manually operated pinion gear, which action effectively locks the lens turret against the front plate of the camera (Fig. 5). Also, an indexing pin is employed to accurately position the turret and to center the lenses.

Electrical Components

In the design of the camera electrical circuits, protection against weather and mechanical damage, and simplicity with reliability were the prime considerations. To achieve these ends, all wiring is in-

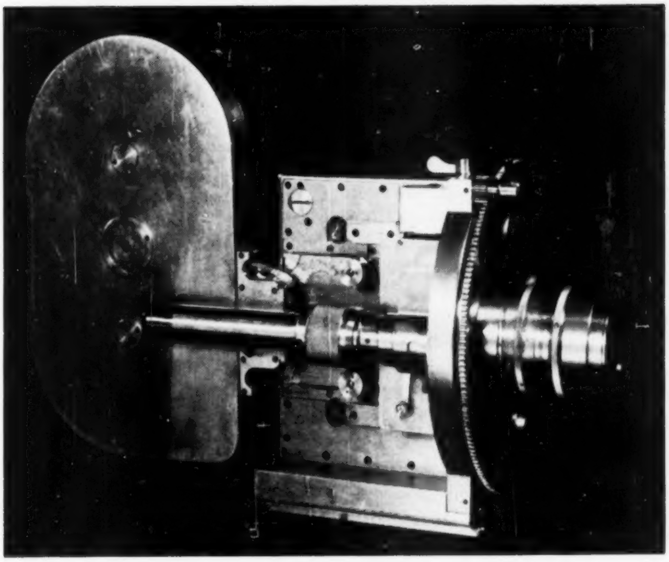


Fig. 5. View showing focusing viewfinder in position.

corporated within the camera body. Attachment of the motor to the camera automatically completes the electrical connections through the built-in plugs in the motor and camera base. This feature provides firm, self-aligning, wear-compensating mountings for quick attachment and removal of the motor as well as for extreme simplicity

The power-feed receptacle, reverse switch, buckle switch, ON-OFF switch, and red light warning assembly are built as separate units. These electrical assemblies, which are commercially available, may be quickly removed from the camera for replacement or maintenance without disturbing or removing the soldered connections or any parts of the camera. The buckle switch stops the camera and a warning red light flashes when there is loss of loop. Furthermore, when the magazine is improperly positioned the camera will not start.

The pendant hand switch and power-feed cable comprise the external wiring of the camera. Most cameras have the ON-OFF switch on the body of the camera, but in order to eliminate disturbance of the camera by physical contact of the operator during shooting, the switch has been placed on the end of a pendant cord. More important, however, is the fact that the pendant-switch method permits use of relays, timing mechanisms and other remote-control systems as desired.

Television Recording

As reported in numerous articles on the subject of kinerecording, elimination of the phenomenon known as "banding" or "shutter bar" has been extremely difficult to accomplish either by mechanical or electronic means. It is well known that a motion picture camera equipped with a 288° open shutter and operated at the synchronous speed of 24 frames/sec is used to record standard 30 frame/sec commercial telecasts. However, numerous and apparently insignificant factors including shutter flutter, mechanical

backlash, film creepage, distance of the shutter blade from the focal plane, the f/stop of the lens, humidity, temperature, variations in synchronism between the camera drive motor and the television frequency, and frequency variations will produce a certain amount of shutter bar. Normally, two shutter bars will appear when the kinerecording is projected. However, by proper synchronization of the camera with the television scanning frequency, one of the bars can be phased out of the picture area leaving the remaining bar in the center of alternate film frames. The size or width of this bar depends upon the effectiveness of the "video splice"[1] which in turn is dependent upon the forementioned factors of shutter flutter, etc. In general, the practice in commercial television studios has been to introduce all the refinements and tricks of the trade possible and then, by trial and error, adjust the recording camera shutter opening by increments of 0.0001 in. or less until the optimum condition has been determined.

From the point of view of the Navy, this long drawn out calibration procedure is not desirable and cannot be tolerated since the Navy camera will be used at many locations in connection with various television systems. Consequently the Navy's kinerecording equipment must be portable, compact, lightweight, rugged and versatile. Furthermore, quick and easy adjustment of the camera in the field to meet changing electrical and electronic conditions must be within the capabilities of the cameraman.

In order to handle the various types of kinerecording problems both airborne and underwater that are normally encountered in the Navy, several additional features were deemed necessary. It was considered desirable for the cameraman to be able to view the image on the kinescope through the high-power viewfinder (Fig. 5) during camera operation in order to check for the presence of undesirable banding or incorrect phasing. This can be done by inserting a prism into the focal plane of the photographic aperture by manipulation of a small spring-loaded lever located below the focusing tube (Fig. 5). The cameraman may then view the translucent image through the film while kinerecording is in progress, or view the image as reflected by a fine, ground-glass prism when the camera is operating without film. In the first instance, the film acts as a ground glass and the operator actually sees the image that is being exposed and recorded on the film. Viewing of this image during exposure, however, will not result in fogging of the film. In the event that two shutter bars are seen, one of the bars can be "phased out" immediately by rotation of a control knob that will vary the electrical phase position of the armature of the camera synchronous motor with the camera movement. The width of the remaining band may be quickly reduced to a negligible value by use of a screwdriver adjustment of a fine worm gear that changes the shutter opening in microscopic increments.

The object distances normally employed in kinerecording are unusually short — in the neighborhood of 15 to 18 in., and this condition puts a premium on obtaining a sharp focus. A 25 × viewfinder was therefore incorporated in the camera to facilitate quick and accurate focusing.

FCC-approved CBS "Field Sequential" color telecasts can be recorded in color provided a high-aperture lens is employed.[4] Furthermore, use of the 300° open shutter will permit recording of five sequential color fields with film pulldown occurring during the sixth or "blue" field. With the use of this technique, more than 83% of the color information will be recorded as compared to 50% recorded when the 180° shutter is employed. RCA color can also be recorded on color film using a high-speed lens and the 288° open shutter.

Radar Scope Recording

Plan Position Indicator (PPI) radar scope recording,[2-4] unlike television, does not require synchronization although, quite naturally, a new set of problems is introduced. High-speed lenses with apertures of $f/1$ or faster are generally required to record satisfactorily the persistent yellow or green component of the images appearing on PPI radar scopes. High-speed lenses have short back-focus distances which make it necessary to locate the plane of the shutter as close to the focal plane as is physically possible.

In the experimental camera, the 288° open shutter used for kinerecording will be replaced by a shutter with a fixed maximum opening of approximately 310° for radar scope recording purposes. This unusually large shutter opening will permit, in some instances, the use of standard, high-quality $f/1.4$ cine lenses. The high-speed lenses on the camera ($f/0.7$ and $f/0.9$) are approximately three inches in diameter which accounts for the rather large diameter of the lens turret. It may be mentioned in passing that in the design of high-aperture lenses,[5] barrel distortion, astigmatism and other abberrations are tolerated in order to gain the extra speed that is so essential. These lenses, in addition to having relatively poor optical qualities, are very expensive and consequently are employed only when the radar scope light levels are so low that their use becomes necessary.

The importance of radar scope cinematography in the Armed Forces is increasing and with this new camera it will be possible to make scope recordings that previously were not feasible. In the field of radar training-film production, it has been necessary in the past to utilize animation techniques almost exclusively. Actual photography of the radar scope will create the realism that is so essential. For added realism, the film may be projected through a green or amber filter to duplicate more closely the appearance of the radar scope. This realistic effect may also be obtained by projecting the film upon a screen treated with the new green and amber colored fluorescing materials.

Conclusion

The experimental camera is geared primarily to the solution of television and PPI radar recording problems. The heart of the camera, that is, the rapid self-threading feature that permits a magazine to be changed in less than ten seconds, would be highly desirable in professional, recording, amateur and combat motion picture cameras.

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Animation Stand of New Design

By E. H. BOWLDS

An animation stand engineered to meet all requirements of flat-bed stop-motion animation for 16mm and 35mm film is described. It is designed to combine ease of operation with facilities for the most intricate effects shots and special techniques. A unique peg and platen system allows larger field sizes than hitherto available on similar equipment. The use of ball bearings at all friction points eliminates power-driven mechanisms and simplifies maintenance.

IN RECENT YEARS, the widespread use of animation for training films and other nontheatrical productions has stimulated the demand for reliable, compact, easy-to-operate animation equipment which could be economically manufactured so as to be within the reach of the average independent producer. Therefore, a study was made to plan and engineer an animation stand which would fulfill the needs of the greatest possible number of users. Consultation with individual operators, special-effects men and animators, together with our own extensive experience in the animation field, produced a long list of features which should be incorporated into such an animation stand. To combine the most desirable of these features into one unit at economical cost presented a challenging engineering problem.

Presented on October 7, 1952, at the Society's Convention at Washington, D.C., by Benjamin Berg for the author, E. H. Bowlds, E. H. Bowlds Engineering Co., 1507 N. Kingsley, Los Angeles, Calif.

Over two years went into laying the groundwork, revising plans and eliminating unnecessary components, before blueprints were ready to present. Churchill-Wexler Film Productions of Los Angeles were the first to feel that these plans suited their financial and mechanical requirements, and so they sponsored construction of the first model (Fig. 1).

Requirements

This pilot animation stand was to provide the following features:

1. A maximum vertical travel from a close range of $3\frac{1}{2}$ to a 16 field (on the basis of the "Acme" system).
2. A movable table with a horizontal range of 12 in. east or west of the optical center, and a $4\frac{1}{2}$-in. movement north or south from center.
3. A pantograph mechanism with an adjustable pointer on an adjacent field for the purpose of quickly plotting diagonal or irregular movements.
4. A recessed box for back-lighting in the center of the table.
5. 360° rotation of the camera.

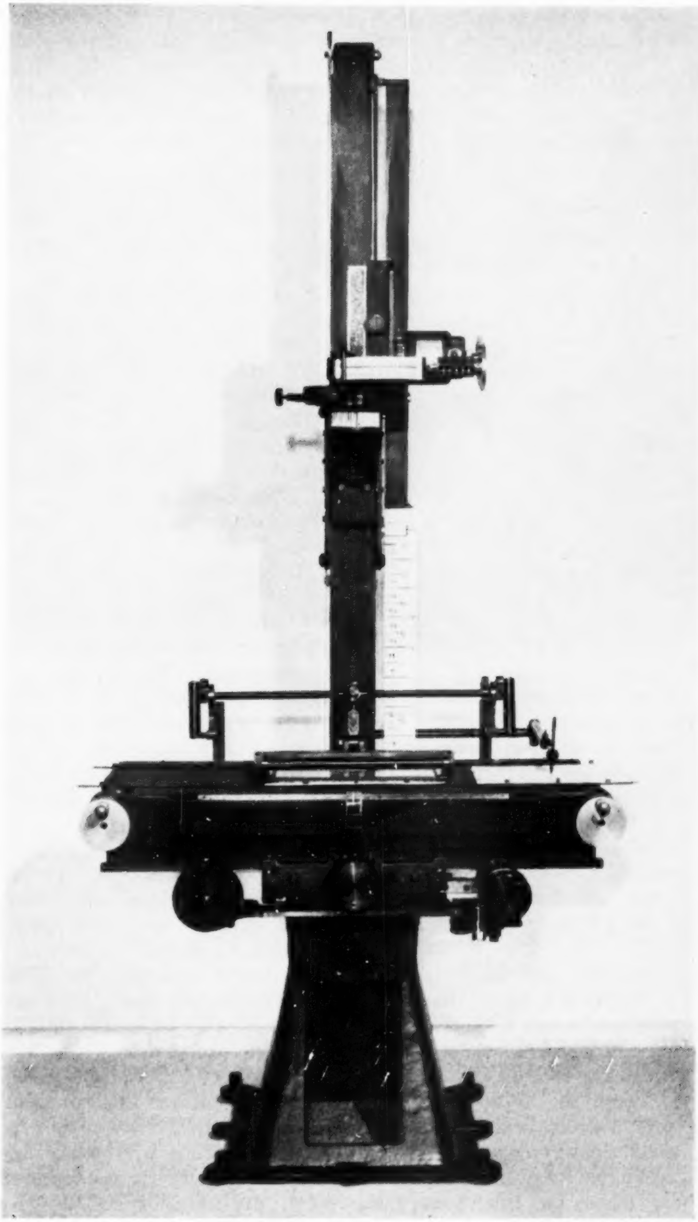


Fig. 1. Assembled animation stand with 16mm Cine Special Camera mounted on camera arm.

6. A peg-bar and platen system which would allow rapid conversion from a standard 12-field to an oversize 16-field.

7. The stand was to accommodate either 16mm or 35mm camera by interchangeable mounts on the vertical carriage.

Design and Construction

The basic construction consists of three components: the base which supports the entire stand, the table base, and the upright for vertical camera movement. These parts are cast-iron, normalized before machining to insure an adherence to close dimensional tolerances.

The base, with flanges, is 24 in. square and has a leveling screw in each corner. Secured to this is the table base with machined top and machined rails to accommodate the north-south movement unit. In back, this table is recessed to allow for the upright, which consists of a heavy tee casting, machined to accommodate ball bearings for a friction-free vertical carriage.

The various components are built on this skeleton structure (Fig. 2). The table is made of seasoned birch. It is secured to heavy steel rails that ride on adjustable ball bearings for the east-west movement. These bearings are under tension to eliminate any play in the table travel and to assure ease of movement. A rule is set into the front of the table for easily visible east-west table calibrations.

The north-south movement is constructed in the same manner; however, this is activated by a lead screw with vee-threads and a bronze hex nut cut in segments, with spring take-up to avoid any backlash. It is calibrated by a tape rule running over a drum behind the hand control, to the right of the operator.

Next, a unique peg-bar system was devised to allow for interchangeable fields. Heavy shafts were mounted in ball bearings at each end of the table. On each shaft are two drums of 12-in. circumference. These are normally set for a 12-field but may be shifted to accommodate larger fields. Over each set of drums is a spring-steel band on heavy tension which can be released by a snap device. Standard peg bars, 3 fields in length, are secured to these steel bands, and are activated by handwheels. The wheel to the right of the operator moves the bottom pegs east or west.

A similar wheel to the left moves the top pegs. The wheels are calibrated so that top and bottom pegs may be moved at different speeds. The peg bars themselves may be removed in a few seconds leaving the sponge-rubber table top clear; or the bars may be spread apart with the adjustable drums to give an oversized field.

A manual platen with a handbar was installed on this model. This platen is of the usual type with water-white glass and a spring device which allows it to remain open or closed. The pressure can be adjusted by placing more tension on the springs. The platen may be removed by loosening one screw. An oversize platen may then be put in its place. This change-over takes but a few seconds and provides a feature which has not hitherto been available on animation stands.

Another important feature on the table is the pantograph. In practice, the use of the pantograph has been found to be an enormous time saver. The operator draws the path of his desired camera movement on a piece of paper equivalent to the field size he is shooting. This path may be a straight line, a curved line or any complex shape. The needle of the pantograph, which is stationary, indicates at all times the relation of the optical center of the camera to the table. Thus by moving the table with the pantograph needle as a reference point, the operator can describe any move he wants, no matter how intricate. This system avoids detailed and lengthy calibrations and considerably speeds up

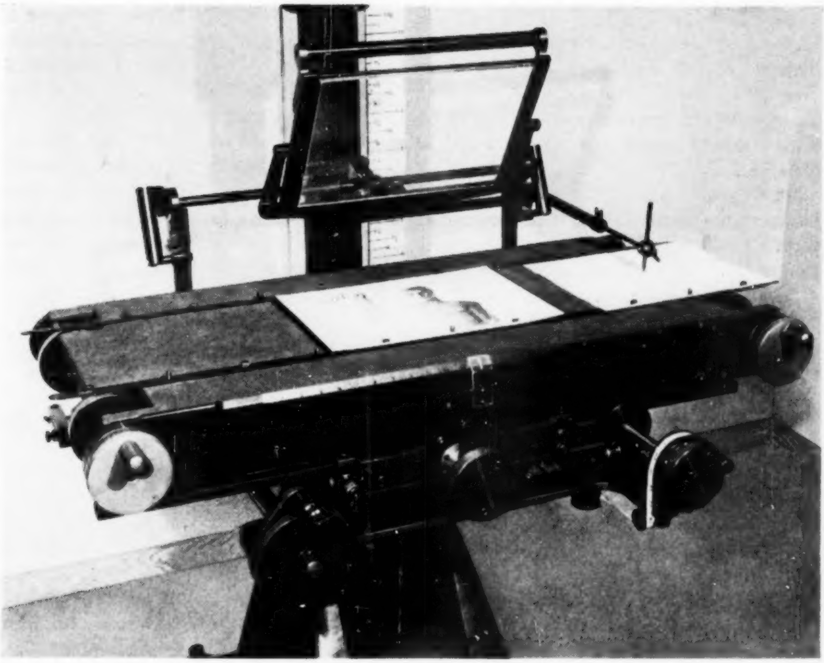


Fig. 2. Table assembly, showing platen, pantagraph, peg bars and control wheels.

shooting time. It may be folded out of the way when not in use or brought into position on the righthand side of the table. The pointer on the pantograph is also adjustable.

The camera carriage is engineered on a ball-bearing system similar to that used on the table. It follows the precision-machined vertical track under heavy tension to assure the same accuracy of movement. The carriage is activated on a steel cable arranged for pulley action. The operator controls this mechanism by a handwheel to his left. Combined with this handwheel is a brake or clutch to hold the vertical unit in any position, and to control the amount of camera weight transmitted to the handwheel.

Vertical movements, as small as the width of the hair line on the vertical scale, are easily controlled by the operator. This is desirable for making smooth vertical trucks. By releasing the clutch, the entire vertical carriage can be moved up or down very rapidly and the fact that ball bearings have been used at all friction points, both rotary and sliding, has made it almost effortless to make any of the intricate movements required of this equipment.

Counterweights were considered to relieve the pressure on the manual control of the vertical movement. On the pilot model, this unit functioned so easily that no counterweights were necessary. However, they may be added, should a heavier camera demand it.

Next on the vertical unit (Fig. 3), placed on a pivotal point over the optical axis, is a ring which allows 360° rotation

of the camera. The ring rotates on a 7-in. bearing which can be locked at any degree. Calibrations are on the edge directly visible to the operator. A $4\frac{1}{2}$-in. aperture in the center will accommodate a large camera lens or lens bell for focusing.

The camera mount is secured directly to this ring with wing nuts and registry pins. Both rotation disc and camera mount have adjusting screws for vertical drift and field rotation.

The camera assembly on the pilot model includes an Eastman Kodak 16-mm Cine Special camera, a Richardson animation motor, and a fading mechanism coupled with the camera's dissolving shutter. Two important considerations influenced the design of the shutter control and coupling device. First, there could be no backlash between the calibrating arm and the camera's shutter. Secondly, the position of the control itself is important. Because fades and dissolves take up a large part of the operator's time in animation shooting, these controls should be immediately accessible and visible. Both these considerations were satisfied by the inclusion of a horizontal quadrant directly in front of the operator's line of sight and conveniently in reach from a sitting position. This quadrant contains the shutter calibrations from 0 to 100% expanded over a 6-in. scale. The pivoted arm which is coupled to the camera's shutter mechanism holds a scribed plastic window directly over the chart on the quadrant. Fades of any length are accomplished by moving this window horizontally over the stationary calibrated chart.

A synchronous Richardson Stop-Motion Motor was selected for the camera drive. This motor is noiseless in operation and the design insures uniform exposure on continuous run as well as single frames, forward or reverse. It is also easily interchanged between 16mm or 35mm cameras and incorporates a large-size frame counter. The motor can be activated by a foot switch or a hand button. The on-off, forward-reverse switches are mounted in a small control box which may be placed within convenient reach of the operator.

A bell-shaped ring is secured to the focusing scale of the Ektar Lens in use on the pilot model. This bell is calibrated in quarter-fields to correspond with the vertical movement of the camera mount. The bell attachment expands the focus calibrations to over double the radius of the original lens focus ring. To focus the lens, the calibrated bell is rotated behind a scribed Lucite bar.

The lens aperture is adjusted by moving a 3-in. arm which is secured to the f/stop ring of the Ektar lens.

This entire camera assembly, including the motor unit, may be removed through the use of two wing nuts. Registry pins insure accurate registration of the optical system with the mount's rotating axis. In this way, a very rapid change-over can be made from a 16mm to a 35mm camera.

Finally, a light box $9 \times 6 \times 12$ in. was incorporated into the table (Fig. 4) to allow photography of pencil tests or transparencies. The light source may be flourescents, or a grid of closely spaced neon tubing.

The overall dimensions of the stand are as follows:

Floor to top of upright, 8 ft;
Width of table, east-west, $3\frac{1}{2}$ ft;
Front of table to rear of assembly, 3 ft;
Height of table, 33 in.;
Face of upright to optical center, 14 in.;
Maximum vertical camera travel, 45 in.;
Maximum east-west table movement, 12 in. from center; and
Maximum north-south table movement, $4\frac{1}{2}$ in. from center.

All exposed surfaces of the equipment are black anodized to avoid light reflections getting back to the optical system.

Lights to illuminate the platen are usually hung from the ceiling or the wall. One 500-w Baby Keg light of the Mole-

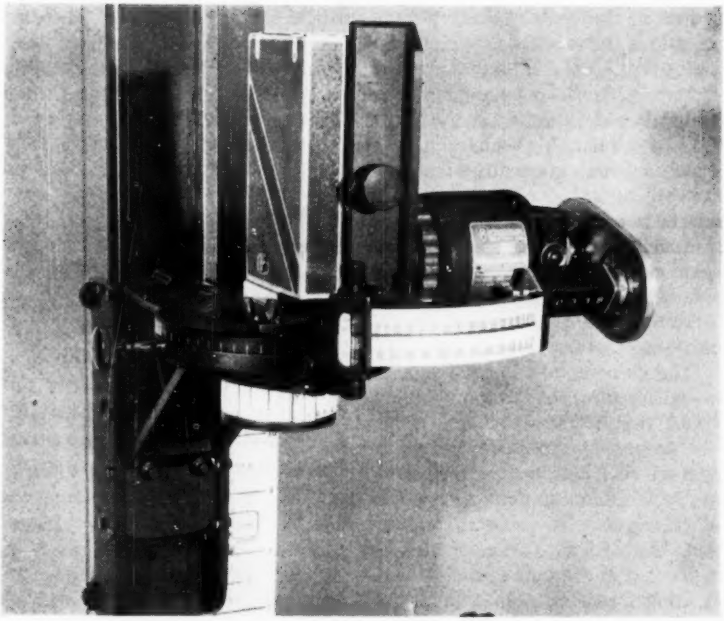


Fig. 3. Camera mount, fading and focusing mechanisms and stop-action motor.

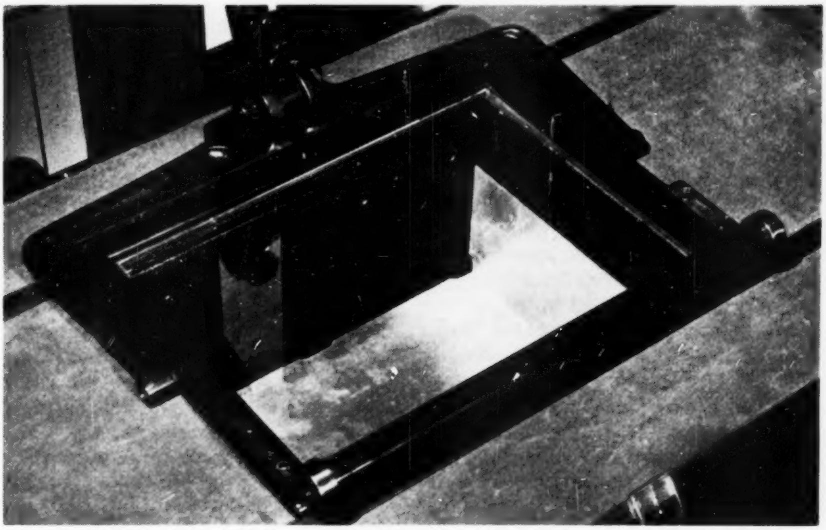


Fig. 4. Light well, directly underneath the platen.

Richardson or Bardwell McAlister type, on each side of the stand, has been found to provide an evenly illuminated field whose intensity can be conveniently controlled. Polaroid filters over the light source and the lens help eliminate flashes from transparent overlays and other undesirable reflections.

A few words are in order to illustrate briefly the simplicity of putting the stand into operation.

The leveling bolts in the base are first adjusted to compensate for any irregularities in the floor and to level the stand itself. The camera unit is then placed on the registry pins, the wing nuts tightened, and two adjustments are made. First the camera aperture is projected to an arbitrary rectangle on the table and the camera is rotated to determine if the optical axis is exactly perpendicular to the plane of rotation. Three small setscrews, located at the base of the camera mount, allow for quick adjustment of the mount to insure rotation of the camera on exact optical center.

The second camera adjustment is for possible drift during the vertical movement of the camera mount. If the axis of the lens is not exactly parallel to the line of vertical movement, the projected aperture image will drift either north, south, east or west during a move from a small to a large field. The amount of drift depends on the relationship of the lens axis to the vertical movement. The slightest deviation from the small tolerances we allowed ourselves would introduce this drift. To compensate for possible errors or dimensional changes, four setscrews are located in the underside of the camera mount. These screws may be adjusted to insure elimination of any drift as the camera moves from the closest to the largest fields. It might be noted that in the pilot model there was no measurable drift, so the setscrews were left in neutral position.

The peg bars and table bed may now be centered north, south, east and west by the same aperture projection technique. The field size and focus calibrations are made and film tests are run to verify all adjustments and calibrations. Once these adjustments are made and the setscrews tightened, they need never be changed as long as the stand is not bodily moved from one place to another.

Accessories

Because of the simplified basic design, it is possible to add a number of accessories for situations requiring special equipment. The present hand-operated platen may be replaced with a mechanized platen movement. Air and hydraulicly activated mechanisms were considered for a foot-operated platen. However, it was felt that these devices require careful maintenance to be trouble-free. So a new design was evolved which operates on a motor-driven cam. This should have the advantage of being almost noiseless and will require little, if any, maintenance. An auxiliary set of flip pegs may be installed on the table, either north or south, to provide two additional stationary levels when both peg bars are being moved. Side pegs may also be added for such effects as panning long backgrounds, north and south through the field, although the ease of rotating the camera to 90° will take care of most of such requirements.

Conclusion

In operation, this simplified animation stand has proved its merits in timesaving. All controls may be conveniently reached from a sitting position. The stand has also proved equal to all types of intricate movements. The pantograph has cut shooting time considerably because all moves are simple to plot. The accurate calibrations within visual range give the operator a sense of assurance of his relative positioning at all times. In the mechanism itself, the elimination of backlash or play relieves all mental calculations for such discrepancies. The

absence of mechanized units has greatly simplified maintenance, and the completely quiet functioning of all moving parts has helped increase the efficiency of the cameraman. Rapid and rhythmic operation has been encouraged because all the controls are within minimum reach.

We believe this equipment fulfills the goal we set out to achieve: a versatile animation stand, economical to manufacture.

Acknowledgment

The author would like to acknowledge the sponsorship of this pilot model by Churchill-Wexler Film Productions whose staff, together with Lee R. Richardson, of the Richardson Camera Co., contributed through cooperation in technical consultations. The author is also grateful for the suggestions and encouragement of all those members of the animation industry who have shown interest in this new project.

Standards PH22.1, –.84, –.85 and –.92 Positive-Negative Raw Stock Dimensions; 16mm Projection Lamps; Enlargement Ratio

On January 8, 1953, the American Standards Association approved four new standards which are published on the following pages.

PH22.1-1953, Dimensions for 35mm Motion Picture Film — Alternate Standards for Either Positive or Negative Raw Stock.

PH22.84-1953, Dimensions for Projection Lamps Medium Prefocus Ring Double-Contact Base-Up Type for 16mm and 8mm Motion Picture Projectors.

PH22.85-1953, Dimensions for Projection Lamps Medium Prefocus Base-Down Type for 16mm and 8mm Motion Picture Projectors.

PH22.92-1953, Enlargement Ratio for 16mm to 35mm Optical Printing.

The first of the above standards was developed by the Film Dimensions Committee under the chairmanship of E. K. Carver and was published for trial and comment in the April 1949 and September 1951 *Journals*. It is the latter version which has now been given final approval.

The next two standards were initiated by the Committee on 16mm and 8mm Motion Pictures, at that time chaired by H. J. Hood. After publication in the February 1951 *Journal*, and in addition to attention in the usual cinematographic standards channels, these standards were also reviewed by the ASA Sectional Committee on Electric Lamp Bases and Holders, C81. This group proposed several modifications of PH22.84 which were subsequently accepted and are now incorporated in the final standard.

PH22.92 is a product of the Laboratory Practice Committee, J. G. Stott, Chairman. This was published as a proposal in the January 1952 *Journal* and was approved without change.—*H.K.*

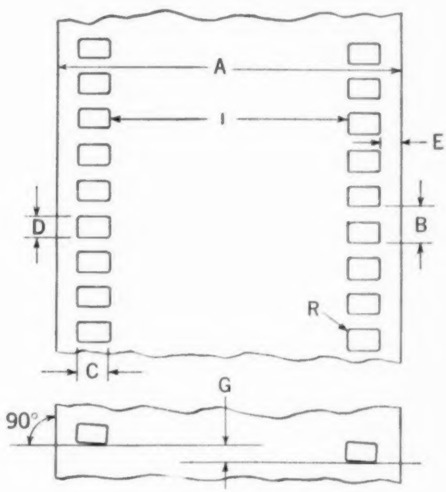
American Standard

Dimensions for 35mm Motion Picture Film Alternate Standards for Either Positive or Negative Raw Stock

ASA
Reg. U. S. Pat. Off.

PH22.1–1953

*UDC 778.5.77.021



Dimensions	Inches	Millimeters
A	1.377 ± 0.001	34.980 ± 0.025
B	0.1870 ± 0.0005	4.750 ± 0.013
C	0.1100 ± 0.0004	2.794 ± 0.01
D	0.0730 ± 0.0004	1.85 ± 0.01
E	0.079 ± 0.002	2.01 ± 0.05
G	Not > 0.001	Not > 0.025
I	0.999 ± 0.002	25.37 ± 0.05
L*	18.700 ± 0.015	474.98 ± 0.38
R	0.013 ± 0.001	0.330 ± 0.025

These dimensions and tolerances apply to the material immediately after cutting and perforating.

* This dimension represents the length of any 100 consecutive perforation intervals.

Approved January 8, 1953, by the American Standards Association, Incorporated
Sponsor: Society of Motion Picture and Television Engineers

*Universal Decimal Classification

Printed in U. S. A.
ASA½M253

Price, 25 Cents

Appendix

(This Appendix is not a part of the American Standard Dimensions for 35mm Motion Picture Film—Alternate Standards for Either Positive or Negative Raw Stock, PH22.1–1953.)

The dimensions given in this standard represent the practice of film manufacturers in that the dimensions and tolerances are for film immediately after perforation. The punches and dies themselves are made to tolerances considerably smaller than those given, but owing to the fact that film is a plastic material, the dimensions of the slit and perforated film never agree exactly with the dimensions of the punches and dies. Shrinkage of the film, due to change in moisture content or loss of residual solvents, invariably results in a change in these dimensions during the life of the film. This change is generally uniform throughout the roll.

The uniformity of perforation is one of the most important of the variables affecting steadiness of projection.

Variations in pitch from roll to roll are of little significance compared to variations from one sprocket hole to the next. Actually, it is the maximum variation from one sprocket hole to the next within any small group that is important.

Perforations of this size and shape were first described in the Journal of the SMPE in 1932 by Dubray and Howell. In 1937, a subcommittee report reviewed the work to date. The main interest in the perforation at that time was in its use as a universal perforation for both positive and negative film. The perforation has been adopted as a standard at this time largely because it has a projection life comparable to that of the perforation used for ordinary cine positive film (American Standard Cutting and Perforating Dimensions for 35mm Motion Picture Positive Raw Stock, Z22.36–1947, or the latest revision thereof approved by the American Standards Association, Incorporated), and the same overall dimensions as the perforations used in the negative film (American Standard Cutting and Perforating Dimensions for 35mm Motion Picture Negative Raw Stock, Z22.34–1949, or the latest revision thereof approved by the American Standards Association, Incorporated). It should be particularly noted that although the present standard has the same overall dimensions as the older cine negative perforation, positioning pins or sprocket teeth made to fit this perforation exactly will injure the corners of the cine negative perforation.

PH22.1–1953

American Standard

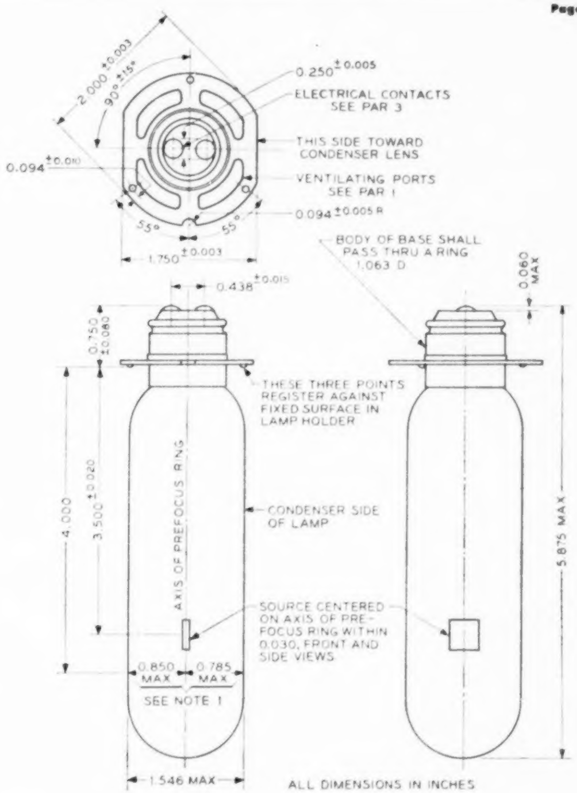
Dimensions for Projection Lamps Medium Prefocus Ring Double-Contact Base-Up Type for 16mm and 8mm Motion Picture Projectors

ASA Reg. U. S. Pat. Off.

PH22.84–1953

*UDC 778.55:621.326.73

Page 1 of 2 pages



1. Scope. The purpose of this standard is to establish, for the type of lamp shown, the dimensions essential to interchangeability of lamps in projectors. It is not intended to prescribe either operating characteristics or details of design such as the shape of the ventilation ports or method of attachment of the prefocus ring to the base.

2. Operating Position. Lamps of this type are intended to be burned with the axis in an essentially vertical position, and with the base at the top.

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3. Electrical Contacts. The drawing indicates the area which the electrical members of the lamp holder should contact. It is not intended to dictate the shape of the terminals on the lamp; however, they should not exceed boat-shaped areas 0.250 inch wide by 0.410 inch long with the long axes parallel to the plate on the flange. With lamps of this type, the prefocus ring is not an electrical contact.

Note 1. These dimensions define the maximum excursion of the bulb surfaces from the base axis toward the condensing lenses and the mirror at the points indicated when the lamp is inserted in a holder which rotationally positions the lamp as shown in the end view of the base. Condensing lenses, the mirror, and their mounts must therefore be so located as to insure adequate clearance between these parts and the bulb surface.

Note 2. For medium prefocus base-down projection lamps, see American Standard Dimensions for Projection Lamps Medium Prefocus Base-Down Type for 16mm and 8mm Motion Picture Projectors, PH22.85–1953, or the latest revision thereof approved by the American Standards Association, Incorporated.

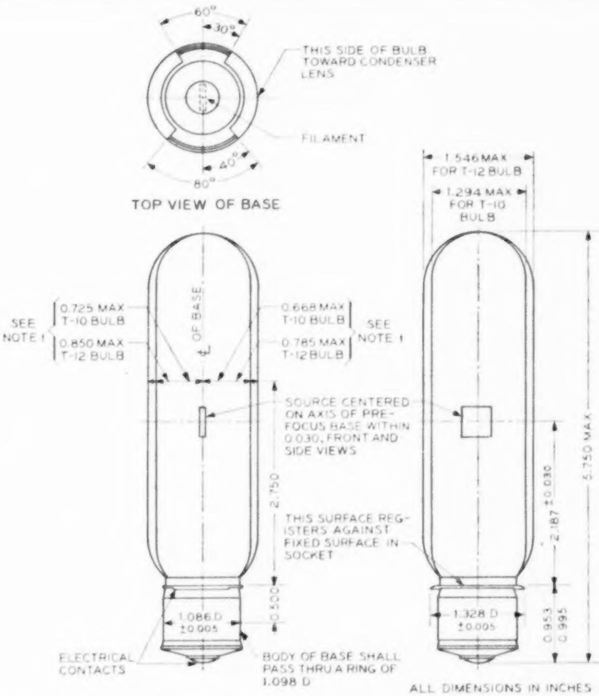
American Standard

Dimensions for Projection Lamps Medium Prefocus Base-Down Type for 16mm and 8mm Motion Picture Projectors

ASA
Reg. U. S. Pat. Off.

PH22.85–1953

*UDC 778.55.621.326.73



1. Scope. The purpose of this standard is to establish, for the type of lamp shown, the dimensions essential to interchangeability of lamps in projectors. It is not intended to prescribe either operating characteristics or details of design.

2. Operating Position. Lamps of this type are intended to be burned with the axis in an essentially vertical position, and with the base at the bottom.

Note 1. These dimensions define the maximum excursion of the bulb surfaces from the base axis toward the condensing lenses and the mirror at the points indicated when the lamp is inserted in a holder which rotationally positions the lamp as shown in the end view of the base. Condensing lenses, the mirror, and their mounts must therefore be so located as to insure adequate clearance between these parts and the bulb surface.

Note 2. For medium prefocus ring double-contact base-up projection lamps, see American Standard Dimensions for Projection Lamps Medium Prefocus Ring Double-Contact Base-Up Type for 16mm and 8mm Motion Picture Projectors, PH22.84–1953, or the latest revision thereof approved by the American Standards Association, Incorporated.

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*Universal Decimal Classification

Printed in U. S. A.
ASA½M253

Price, 25 Cents

American Standard

Enlargement Ratio for 16mm to 35mm Optical Printing

ASA
Reg. U. S. Pat. Off.

PH22.92–1953

*UDC 778.5:778.13

In the enlargement printing of 16mm film to 35mm film, a magnification of 2.21 ± 0.01 shall be employed, and the center of the 16mm frame as enlarged shall coincide with the center of the 35mm aperture in the enlarging printer.

Note 1. This will mean a scanned area on the 16mm frame of 0.272 inch ± 0.002 × 0.373 inch ± 0.002 will be projected through the 35mm projector aperture when the print is used in the theater. This corresponds to a frame of 0.284 inch × 0.380 inch if the 16mm original were projected directly.

Note 2. The scanned area of the 16mm frame in the printer as enlarged to the 35mm camera aperture is 0.286 inch ± 0.002 × 0.393 inch ± 0.002.

Note 3. Attention of camera users is invited to the desirability of using a camera finder matte 0.272 inch ± 0.002 × 0.373 inch ± 0.002 when exposing 16mm film to be enlarged to 35mm film.

Note 4. In enlargement from 16mm positive or reversal original to 35mm negative a black frame line will result on the final 35mm print. In the case of enlargement from 16mm negative directly to 35mm print, white frame lines will result. If the height of the 16mm aperture for enlargement from 16mm negative to 35mm print is made 0.300 inch, the resulting aperture image on the 35mm print will be from 0.660 to 0.666 inch in height. While the frame line will not be entirely black, there would be a black margin on either side of the image which would give an additional safety factor in projection.

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73d Semiannual Convention

Papers are now a first order of business. Papers Committee Vice-Chairmen, listed in the December *Journal*, have been active with 73d Convention Author's Forms issued at the end of December by W. H. Rivers, Papers Committee Chairman. Bill Rivers has slightly revamped the "Hints to Authors," especially to try to get better presentations of lantern slides at Conventions. With the Author's Forms for this Convention goes a copy of American Standard Dimensions for Lantern Slides, Z38.7-1950, to which the American Standards Assn. permitted the SMPTE to add some recommendations for lettering as a minimum guidance for readability.

Ralph Lovell, Program Chairman, already has some sessions sketched out, particularly for a group of papers about outdoor theaters. SMPTE's television papers for this convention will be scheduled in a coordinated plan with the National Association of Radio and Television Broadcasters. The NARTB meeting is being held at the Biltmore Hotel in Los Angeles on April 28–May 1. The SMPTE Convention begins on April 27. It is expected that many will want to see the NARTB exhibits.

The general outline of the 73d Convention will be mailed about March 2 as the Advance Notice.

A new feature expected to be introduced at this Convention by Convention Vice-President J. W. Servies and Local Arrangements Chairman Vaughn C. Shaner is opening of the Registration Desk a day earlier, on Sunday, at the Los Angeles Statler.

Now is the time—the scheduled deadline is February 16—to get Author's Forms in for the Los Angeles Program. Forms and information are available, always from Society headquarters, but better from the Papers Committee member in your area or organization:

Chairman: W. H. Rivers, Eastman Kodak Co., 342 Madison Ave., New York 17.

73d Convention Program Chairman: Ralph E. Lovell, 2743 Veteran Ave., West Los Angeles 64, Calif.

For Washington: J. E. Aiken, 116 N. Galveston St., Arlington 3, Va.

For New York: Skipwith W. Athey, 201 Spring St., Mt. Kisco, N.Y.

For Chicago: Geo. W. Colburn, 164 N. Wacker Dr., Chicago 6, Ill.

For 73d Convention High-Speed Photography: Carlos H. Elmer, 410B Forrestal St., China Lake, Calif.

For Canada: G. G. Graham, National Film Board of Canada, John St., Ottawa, Canada

For High-Speed Photography: John H. Waddell, 850 Hudson Ave., Rochester 21, N.Y.

Papers Committee Members

James A. Anderson, Alexander Film Co., Alexander Film Bldg., Colorado Springs, Colo.

Mark Armistead, 1041 N. Formosa Ave., Hollywood 46, Calif.

D. Max Beard, Naval Ordnance Laboratory, White Oak, Silver Spring, Md.

Richard Blount, General Electric Co., Nela Park, Cleveland, Ohio

R. P. Burns, Balaban & Katz, Great States Theaters, 177 N. State St., Chicago 1, Ill.

Merle H. Chamberlin, Metro-Goldwyn-Mayer Studios, 10202 Washington Blvd., Culver City, Calif.

P. M. Cowett, Dept. of the Navy, Bureau of Ships, Washington 25, D.C.

E. W. D'Arcy, De Vry Corp., 1111 W. Armitage Ave., Chicago 14, Ill.

W. H. Deacy, Jr., 231 E. 76 St., New York 21, N.Y.

W. P. Dutton, 732 N. Edison St., Arlington 3, Va.

Barry T. Eddy, 10569 Selkirk Lane, Los Angeles, Calif.

Karl Freund, 15024 Devonshire St., San Fernando, Calif.

Jack K. Glass, 10858 Wagner St., Culver City, Calif.

R. N. Harmon, Westinghouse Radio Stations, Inc., 1625 K St., N.W., Washington, D.C.

Scott Helt, Allen B. Du Mont Laboratories, Inc., 2 Main Ave., Passaic, N.J.

C. E. Heppberger, 231 N. Mill St., Naperville, Ill.

S. Eric Howse, 2000 West Mountain St., Glendale 1, Calif.

L. Hughes, Hughes Sound Films, 1200 Grant St., Denver, Colo.

P. A. Jacobsen, Campus Studios, 100 Meany Hall, University of Washington, Seattle, Wash.

William Kelley, Motion Picture Research Council, 1421 N. Western Ave., Hollywood 27, Calif.

George Lewin, Signal Corps Photographic Center, 25-11—35 St., Long Island City 1, N.Y.

Glenn E. Matthews, Research Laboratory, Eastman Kodak Co., Rochester 10, N.Y.

Pierre Mertz, Bell Telephone Laboratories, Inc., 463 West St., New York 14.

Harry Milholland, Du Mont TV Network, Station WABD, 515 Madison Ave., New York 22.

W. J. Morlock, General Electric Co., Electronics Park, Syracuse, N.Y.

Herbert W. Pangborn, 6512 Orion St., Van Nuys, Calif.

Bernard D. Plakun, General Precision Laboratory, Inc., 63 Bedford Rd., Pleasantville, N.Y.

Carl N. Shipman, 9544 Burma Rd., Rivera, Calif.

S. P. Solow, Consolidated Film Industries, Inc., 959 Seward St., Hollywood 38, Calif.

J. G. Stott, Du-Art Film Laboratories, 245 W. 55 St., New York 19.

W. L. Tesch, Radio Corporation of America, RCA Victor Div., Front & Cooper Sts., Camden, N.J.

Lloyd Thompson, The Calvin Co., 1105 Truman Rd., Kansas City 6, Mo.

M. G. Townsley, Bell & Howell Co., 7100 McCormick Rd., Chicago 45, Ill.

Allan L. Wolff, Westrex Corp., 6601 Romaine St., Hollywood 38, Calif.

Roy L. Wolford, 3434 W. 110th St., Inglewood 2, Calif.

Royal Photographic Society Centenary

The Royal Photographic Society of Great Britain celebrates its Centenary in 1953 and will hold an International Conference on the Science and Applications of Photography in London from Saturday, September 19, to Friday, September 25, 1953.

The Conference will cover many aspects of the science, technique and applications of photography and will be divided into sections dealing with:

I. Photographic Science (including theory of latent image and development, sensitization, sensitometry, resolving power, granularity, properties of photographic materials).

II. Cinematography and Colour Photography.

III. Technique and Applications of Photography (including industrial radiography, photomicrography, spectroscopy, aerial photography, photogrammetry, high-speed photography, nuclear track recording, and other physical chemical and biological applications; photocopying, apparatus, process, manipulations).

IV. Photomechanical Processes.

V. History, Literature (including abstracting and documentation) and Training in Photography.

All persons taking an interest in photography or its applications are cordially invited to attend the Conference, and to submit papers for discussion. Titles and indications of the scope of such papers should be submitted before February 1, 1953.

Preparation, Presentation and Publication of Papers

It is the intention of the Organizing Committee to publish the accepted papers soon after the Conference, and to distribute preprints as early as possible before its opening. Titles and an indication of the scope of papers should be submitted before February 1, 1953. The full text (in duplicate) of all addresses, reports and papers

must be in the hands of the Organizing Committee before May 1, 1953.

In order to allow ample time for discussion, the authors will be accorded only a few minutes to introduce their papers and to outline their conclusions. A longer speaking time will be granted only for the introduction by the Chairman of each section and for specially invited addresses and papers. Details on the form of the typescripts and illustrations, on the publication, reprinting, etc., will be sent to all intending contributors. The Committee has absolute discretion as to the acceptance of papers. No information of any kind concerning rejected communications will be published. No paper shall be published before it has been read at the Conference.

It is to be emphasized that papers submitted for the Conference will receive every consideration, but it will not necessarily mean that they will be accepted for presentation or publication.

[The requirements of the Royal Photographic Society may be of particular interest to SMPTE authors and committeemen, for the sake of comparison.]

Those who can plan to participate in this International Conference should send by air mail or cable their advice and abstract to Mr. C. S. Brasier, 4 Romney Road, Southcourt, Aylesbury, Bucks, England. Mr. Brasier is particularly interested in high-speed photography but his interest in the SMPTE generally should prompt whatever cooperation may be feasible on the part of any of this Society's members.

Engineering Activities

The rules of the American Standards Association require periodic review of all standards over three years old for reaffirmation, revision or withdrawal. In accordance with this procedure, the Engineering Committees have been participating this past year in an extensive review of those cinematographic standards which were issued prior to 1949. The status of this activity is presented below.—*Henry Kogel*, Staff Engineer.

**Std.*	*Title*	*Status*
.2-1946,	35mm Film-Usage in Camera	Revision proposed by the Sound Committee, approved by the Standards Committee, and is now being reviewed by ASA Sectional Committee PH22.
.3-1946,	35mm Film-Usage in Projector	
.4-1941,	Projection Reels for 35mm Film	Now being reviewed by the Film Projection Practice Committee.
.5-1947,	Dimensions for 16mm Double-Perforated Film	Revision proposed by 16mm and 8mm Committee, approved by Standards Committee, Published in December 1952 *Journal* for 3-month trial and comment.
.9-1946,	16mm Double-Perforated Film-Usage in Camera	Second Draft being prepared within 16mm and 8mm Committee
.10-1947,	16mm Double-Perforated Film-Usage in Projector	
.12-1947,	Dimensions for 16mm Single-Perforated Film	Same as .5 above.
.15-1946,	16mm Single-Perforated Film-Usage in Camera	16mm and 8mm committee now voting on these proposed revisions.
.16-1947,	16mm Single-Perforated Film-Usage in Projector	
.17-1947,	Dimensions for 8mm Film	Film Dimensions Committee now voting on proposed revision.

* All these standards had the Z22 designation. This is now being replaced by PH22 to precede the decimal point in the number of each standard.

*Std.	Title	Status
.21-1946,	8mm Double-Perforated Film-Usage in Camera	Revision, purely editorial in nature, proposed by the 16mm and 8mm Committee, approved by the Standards Committee, and is now being reviewed by ASA Sectional Committee PH22.
.22-1947,	8mm Double-Perforated Film-Usage in Projector	
.23-1941,	Projection Reels for 8mm Film	Requires revision by 16mm and 8mm Committee.
.27-1947,	Determining Transmission Density of Film	Reaffirmed by the Laboratory Practice Committee, and now being reviewed by the Standards Committee
.28-1946,	Projection Rooms and Lenses for Theaters	Requires revision by Film Projection Practice Committee.
.31-1946,	Definition for Safety Film	Requires revision. Is being studied by ASA Sectional Committee PH1.
.33-1941,	Nomenclature for Electrical Filters	Approval withdrawn by ASA October 1952. Withdrawal notice published November 1952 *Journal*.
.35-1947,	16-Tooth 35mm Projector Sprocket	Now being reviewed by the Film Projection Practice Committee.
.36-1947,	Dimensions for 35mm Positive Film	Film Dimensions Committee now voting on proposed revision. Only change is method of indicating dimension G.
.37-1944,	Raw Stock Cores for 35mm Film	Reaffirmed by Film Dimensions Committee and now being reviewed by Standards Committee.
.38-1952,	Raw Stock Cores for 16mm film	Revision was approved October 1952. Published in November 1952 *Journal*.
.39-1944,	Screen Brightness for 35mm Motion Pictures	Revision proposed by Screen Brightness Committee, approved within SMPTE, published for trial and comment in May 1952 *Journal*, and is now being reviewed by the Photographic Standards Correlating Committee of ASA.
.41-1946,	Sound Records and Scanning Area 16mm Sound Prints	Revision is being drafted by the Laboratory Practice Committee.
.42-1946,	16mm Sound Focusing Test Film	Sound Committee is now voting on proposed revision.
.43-1946,	16mm 3000-Cycle Flutter Test Film	Reaffirmed by the Sound Committee and is now being reviewed by the Standards Committee.
.44-1946,	16mm Multi-Frequency Test Film	
.45-1946,	16mm 400-Cycle Signal Level Test Film	Same as .42 above.
.46-1946,	16mm Positive Aperture and Image Size for Positive Prints From 35mm Negatives	Same as .27 above.
.47-1946,	Negative Aperture Image Size 16mm Duplicate Negatives from 35mm Positive Prints	Same as .27 above.
.48-1946,	Printer Aperture Contact Printing 16mm Positive From 16mm Negatives	Same as .27 above.

* All these standards had the Z22 designation. This is now being replaced by PH22 to precede the decimal point in the number of each standard.

*Std.	Title	Status
.49-1946,	Printer Aperture Contact Printing 16mm Reversal and Color Reversal Duplicate	Is being reviewed by Laboratory Practice Committee.
.50-1952,	Reel Spindles for 16mm Projectors	Reaffirmed by ASA November 1952 and published in the December 1952 *Journal*.
.51-1946,	Intermodulation Tests on Variable-Density 16mm Prints	
.52-1946,	Cross-Modulation Tests on Variable-Area 16mm Prints	Reaffirmed by the Sound Committee and is now being reviewed by the Standards Committee.
.53-1946,	Revolving Power of 16mm Projector Reels	Revision proposed by Optics Committee, approved within SMPTE, and is now being reviewed by the Photographic Standards Correlating Committee.
.54-1946,	16mm Travel Ghost Test Film	Same as .23 above.
.55-1947,	35mm Release Prints	Revision required. Draft is being prepared by the Laboratory Practice and Films for Television Committees.
.56-1947,	Nomenclature for Film Use in Studios and Processing Laboratories	Is being revised by Laboratory Practice Committee.
.57-1947,	Buzz Track Test Film 16mm Reproducers	Standard .57 and the remainder of those listed here have been reaffirmed by the Sound Committee and are now being reviewed by the Standards Committee.
.58-1947,	Picture Projection Aperture 35mm Projectors	
.60-1948,	Theater Sound Test Film for 35mm Reproducing Systems	
.62-1948,	35mm Sound Focusing Test Film (Lab. Type)	
.65-1948,	35mm Scanning-Beam Uniformity Test Film (Service Type)	
.66-1948,	35mm Scanning-Beam Uniformity Test Film (Lab. Type)	
.67-1948,	35mm 1000-Cycle Balancing Test Film	
.69-1948,	Sound Records and Scanning Area of Double-Width Push-Pull Sound Prints (Normal Centerline Type)	
.70-1948,	Sound Records and Scanning Area of Double-Width Push-Pull Sound Prints (Offset Centerline Type)	

* All these standards had the Z22 designation. This is now being replaced by PH22 to precede the decimal point in the number of each standard.

Letters to the Editor

Re: Three-Dimensional Motion Picture Nomenclature

[from L. Dudley]

I would like to refer to my letter, and Major Bernier's reply thereto, which appeared in the *Journal* for July 1952.

With regard to a suitable term to define those stereoscopic processes which do not entail the use of individual viewing devices, I think that the term *autostereoscopic* processes is as good as any. This term is in fairly general use in England, and equivalent terms are gaining some ground on the continent. Further, on the writer's recommendation, it has been adopted by the British Standards Institute.

I notice that Major Bernier has repeated some of the information, concerning early pioneers, which I gave in my own letter, but has made one or two errors in this connection. For example, the particular member of the Ives family who is associated with the year 1902 is, as stated in my letter, Frederick Ives (the inventor of the parallax stereogram), and not his son, Dr. H. E. Ives, as inferred by Major Bernier. Dr. H. E. Ives's most important contributions to the art lie in his various proposals for applying the principle of the parallax panoramagram (invented by C. W. Kanolt in 1915) to stereo cinematography.

Referring to the seventh paragraph of Major Bernier's letter, it would appear that Major Bernier agrees that "accommodation" is the correct term, rather than "focus reaction," so it is a little difficult to follow his reason for believing that the latter term would be more easily understood.

With reference to the comments in paragraphs 8 to 10 of Major Bernier's letter, here again I am at a loss to follow his reasoning. My statement to the effect that stereoscopic vision is the net result of the various contributing factors is not based on a fallacy, for the very good reason that my definition of the term is that which is generally accepted. Further, the fact that binocular vision does not always result in the perception of a three-dimensional (or stereoscopic) image has not been in question, so I do not understand why Major Bernier cites several examples to illustrate this point. By so doing, Major Bernier is, in fact, arguing on my side, because he is agreeing that, whilst binocular vision does not always result in the perception of a three-dimensional (or stereoscopic) image, we cannot experience stereoscopic vision *without* binocular vision. Accordingly, the latter factor must be regarded as one of the contributory causes of the former.

I am familiar with the work of Hardy and Perrin, to which Major Bernier refers, and agree that in most circumstances the faculties of accommodation and convergence are interdependent. Such interdependence exists during the viewing of motion pictures, as can be demonstrated experimentally by photographic methods. In my previous letter, when discussing the phenomena causing cinema patrons to make periodic, momentary efforts to accommodate for the "apparent" plane of the image, I stated that this "is sometimes the cause of headaches amongst elderly cinema patrons, whose ocular sensory organs and muscles are, naturally, less responsive than those of younger people." I am very surprised, therefore, to note Major Bernier's comment that he cannot agree with this "since it is common knowledge in ophthalmic practice that they lose their power of accommodation as a result of progressive hardening of the crystalline lens as they grow older." Here, again, it would appear that Major Bernier is not really disagreeing with me, because we are, of course, both in agreement about the progressive deterioration, with age, of the power of accommodation. The important point is that the *effort* to accommodate does not undergo the same, progressive deterioration, and it is the persistence of this effort, regardless of the fact that the organs concerned are no longer fully responsive, which results in strain.

I note that Major Bernier claims to have overcome completely the time parallax problem associated with the alternate frame principle. I would therefore draw attention to the fact that, by definition, an alternate frame system is one in which the

"left-eye" and "right-eye" views are recorded *alternately*. Accordingly, the phenomenon of time parallax is inherent in such systems. In order to eliminate time parallax, the two components of each successive stereoscopic pair must be recorded *simultaneously*, which means, of course, abandonment of the alternate frame principle.

Referring to the penultimate paragraph of Major Bernier's letter, my statement that "the *minimum* rate of occultation necessary to prevent the occurrence of *objectionable* flicker is about 24 per second" is quite correct. In my previous letter I was not referring to the rate of occultation which would be acceptable in a practical system, as the acceptable rate is influenced by screen brightness, picture contrast and other factors. In a practical system the rate of occultation must be sufficiently high to cope with the most severe conditions, necessitating doubling or trebling the minimum rate.

September 16, 1952 L. P. C. J. Dudley
Stereoptics Limited
The Laboratory
Odeon Theatre
Kensington High St.
London, W. 8.

[from John A. Norling]

I have reviewed with interest Mr. L. Dudley's letter of 30 August 1951, Major Robert V. Bernier's letter in reply thereto and Mr. Dudley's comments of 16 Sept. 1952 on Major Bernier's later communication.

These letters confirm my opinion that the Stereoscopic Art needs an authoritative nomenclature, a nomenclature that will make it possible for all authors who will follow it to "speak a common language." It is my hope that the Stereoscopic Committee will soon produce a Glossary of Terms acceptable to all workers in the field. There exist many phases of the art which have been given various terms by different people and there are no textbooks on ophthalmology and optometry which completely cover the field. However, we should not change a term from its established use merely because we think we can express ourselves more clearly than the textbooks have succeeded in doing.

I agree with Mr. Dudley that "*accommodation*" should be used rather than Maj. Bernier's "*focus reaction.*" The term "*autostereoscopic* process (es)" is much to be preferred to the loose term "*composite process* (es)." Composite processes of photography are not part of the stereoscopic art; in fact the familiar "Composigraph," employed extensively in the past as a journalistic stunt, is something that would result only in a confusing stereo movie, if it could be made at all.

An interesting thing about projected stereo is that it calls for a relaxation of accommodation but an active use of the muscles employed in convergence. For this reason it seems advisable to use extreme restraint in employing photographic stunts that require the viewer of projected stereo excessive use of his faculty of convergence. Eyestrain may arise if wide uncoupling of accommodation and convergence are demanded of people.

I agree with Mr. Dudley that the time parallax problem associated with the alternate-frame principle is a serious one, particularly if the individual members of the stereo pairs are photographed alternately. But even if the individual members are photographed simultaneously, alternate projection will almost certainly result in eyestrain, regardless of the projection frequency.

The eyes, or perhaps more properly the visual centers, do not like the delivery of a picture to one eye during an occultation of the other eye. I have observed symptoms of nausea even at projection of 48 frames a second, 24 to each eye, and a flicker frequency of 192. I have used the term "differential flicker," for want of a better term, in discussing the particular problems in alternate-frame projection. Flicker fusion frequency (fff) is a very important matter in ophthalmology and medical practice. Detection of the change in fff in an individual is often of great value in diagnosis.

In connection with fff, research has demonstrated that the average is around 45 to 48 cycles/sec and doesn't vary much with age, but tests for fff are made with a beam of light subtending one degree or less and covering only the fovea, where, as we know, there is less sensitivity to rapid changes in light than in the outer regions of the retina. The motion picture

is seen by quite a large area of the retina and a fairly bright picture usually has a detectable flicker at 96 interruptions a second, 48 periods of brightness and 48 periods of darkness, as occur in projection with a two-bladed shutter at 24 frames/sec. A very limited study of the flicker problem has convinced me that alternate-frame projection of stereo has serious drawbacks. Therefore I cannot agree with Major Bernier's conclusions nor with Mr. Dudley's statement (in his 30 Aug. 1951 letter) that "It is readily demonstrable that the minimum rate of occultation to prevent the occurrence of objectionable flicker is about 24 frames/sec, etc.," even though he confines this to planoscopic projection and even though he qualifies this statement in the last paragraph of his letter of September 16, 1952.

October 1, 1952

John A. Norling
245 W. 55 St.
New York 19, N.Y.

New Members

The following members have been added to the Society's rolls since those last published. The designations of grades are the same as those used in the 1952 MEMBERSHIP DIRECTORY.

Honorary (**H**) Fellow (**F**) Active (**M**) Associate (**A**) Student (**S**)

Agar, H. V., Sales, Watland Brothers. **Mail:** 535 North Brainard, La Grange Park, Ill. (**A**)

Arthur, Hal, University of Southern California. **Mail:** 8569 Nash Dr., Los Angeles 46. (**S**)

Barkes, Gordon S., Projectionist, WBKB Television Station. **Mail:** 4170 West Nelson, Chicago 41, Ill. (**A**)

Belsky, Clarence J., University of Southern California. **Mail:** 430½ South Burlington Ave., Los Angeles 5, Calif. (**S**)

Benns, William E., Jr., Consulting Radio and Television Engineer, 3738 Kanawha St., N.W., Washington, D.C. (**M**)

Bonner, Bob, University of Southern California. **Mail:** 2326 Scarff St., Los Angeles 7. (**S**)

Brokaw, Edgar L., Jr., Lecturer (Motion Picture Editing), University of California at Los Angeles. **Mail:** 129 South Oakhurst Dr., Beverly Hills, Calif. (**A**)

Brokop, Robert J., University of Southern California. **Mail:** 1130 West 36 St., Los Angeles 7, Calif. (**S**)

Browne, Robert A., University of Southern California. **Mail:** 836 W. 41 St., Los Angeles 37, Calif. (**S**)

Caldwell, S. W., President, S. W. Caldwell, Ltd., 150 Simcoe St., Toronto, Ontario, Canada. (**A**)

Caras, Roger A., University of Southern California. **Mail:** 930 W. 36 St., Los Angeles 7, Calif. (**S**)

Cleveland, George, Production Manager, Great Commission Films. **Mail:** 526 Moreno Ave., Los Angeles 49, Calif. (**A**)

Colman, Joel E., University of California at Los Angeles. **Mail:** 3267 Sepulveda Blvd., Apt. 1, Los Angeles 34, Calif. (**S**)

Cowles, William E., Mechanical Engineer; Groupleader, Engineering Visual Aids., General Electric Co. **Mail:** 1556 Clifton Park Rd., Schenectady, N.Y. (**A**)

Croy, Harlan P., General Manager and Treasurer, Film Arts Corp. **Mail:** 1032 N. Sixth St., Milwaukee, Wis. (**M**)

Cunningham, Clairdon E., Research Psychologist (Experimental), U.S. Navy Electronics Laboratory. **Mail:** 3628 Charles St., San Diego 6, Calif. (**M**)

Day, I. M., Supervisor, Northern Electric Co., Ltd., P.O. Box 6124, Montreal, Quebec, Canada. (**M**)

Desrosiers, Robert, Assistant Film Editor, Canadian Broadcasting Corp. (Television). **Mail:** 3757 Carlton Ave., Montreal 26, Quebec, Canada. (**A**)

Dill, James M., Electronic Engineer, UM&F Manufacturing Corp. **Mail:** 12215 Victoria, Los Angeles 34, Calif. (**A**)

Dillard, Albert E., University of Southern California. **Mail:** 1820 West 38 St., Los Angeles 62, Calif. (**S**)

Ebron, Bonifacio M., Jr., University of Southern California. **Mail:** 837 West 36 Place, Los Angeles, Calif. (**S**)

Elias, T. J., Control Chemist (Solutions), Technicolor M.P.S. **Mail:** 4943 Densmore, Encino, Calif. (**A**)

Filizola, Vincent F., Television Engineer, Paramount Television Productions, Inc. (KTLA). **Mail:** 5327 Loma Linda Ave., Hollywood 27, Calif. (**M**)

Friesen, Dietrich P., University of Southern California. **Mail:** 942 West 34 St., Los Angeles 7, Calif. (**S**)

Galminas, Dominic, Director, Cameraman, Editor, Applied Physics Laboratory, Johns Hopkins University. **Mail:** 9805 Warren St., Silver Spring, Md. (**A**)

Ganon, Bob R., Production Manager, TV Ads, Inc., 3839 Wilshire Blvd., Los Angeles 5, Calif. (**M**)

Garcia, Gilberto E., University of Southern California. **Mail:** 1201 South Third Ave., Los Angeles 19, Calif. **(S)**

Ghosh, Ishan, Recordist, c/o Kardar Productions, Parel, Bombay, India. **(A)**

Gill, George H., Television Lighting Sales Engineer, Kliegl Bros. **Mail:** 13 Smith St., Glen Head, N.Y. **(A)**

Green, F. A., Technical Officer, Audio-Visual Aids, International Civil Aviation Organization, 716 International Aviation Bldg., Montreal, Canada. **(M)**

Griffin, William C., Photographic Technologist, U.S. Naval Ordnance Test Station. **Mail:** P.O. Box 637, China Lake, Calif. **(M)**

Gunzburg, M. L., President, Natural Vision Corp. **Mail:** 1710 North La Brea Ave., Hollywood 46, Calif. **(A)**

Gyiaung, Tin, University of Southern California. **Mail:** 837 36 Place, West Aeneas Hall, Los Angeles 7, Calif. **(S)**

Harvey, Douglas G., University of Southern California. **Mail:** 1846 South Cochran Place, Los Angeles 19, Calif. **(S)**

Head, Howard T., Consulting Radio Engineer, A. D. Ring & Co., 342 Munsey Bldg., Washington, D.C. **(A)**

Hedburn, Paul W., Motion Picture Laboratory Manager, Atlas Film Corp. **Mail:** 646 Adams St., Oak Park, Ill. **(A)**

Hedwig, Gordon W., Telecast Films, Inc. **Mail:** 2 Keenan Place, Garden City, N.Y. **(M)**

Holdeman, Don, Cine-Technician, Public Relations Dept., Arabian American Oil Co., Dhahran, Saudi Arabia. **(A)**

Holleran, J. Vinson, Vice-President, McGeary-Smith Laboratories, Inc., 1905 Fairview Ave., N.E., Washington, D.C. **(A)**

Ives, George M., Television Engineer, Maintenance Supervisor, American Broadcasting Co. **Mail:** 4221 Arthur Ave., Brookfield, Ill. **(M)**

Jekste, Alberts Z., Managing Director, Atlantic Films & Electronics, Ltd., 22 Prescott St., St. John's, Newfoundland. **(M)**

Klaeger, Robert H., Vice-President in charge of Television Production, Transfilm, Inc., 35 W. 45 St., New York 19, N.Y. **(M)**

Lapenieks, Vilis, University of Southern California. **Mail:** 2905 South Hoover St., Los Angeles, Calif. **(S)**

Leavenworth, William, University of Southern California. **Mail:** 907 West 28 St., Los Angeles, Calif. **(S)**

LeGault, Joseph W., University of Southern California. **Mail:** 612 West 115 St., Los Angeles 44, Calif. **(S)**

Lewis, Vernon, Motion Picture Producer, 71 W. 45 St., New York 19, N.Y. **(M)**

Lindholm, George W., Jr., Photo Unit Chief, Argonne National Laboratory. **Mail:** 1742 E. 83 Pl., Chicago 17, Ill. **(A)**

Loughren, Arthur V., Engineer, Director of Research, Hazeltine Corp. **Mail:** 22 Broadlawn Ave., Great Neck, N.Y. **(M)**

Marcus, Omar, Technical Consultant, Tri-Art Color Corp., 245 W. 55 St., New York 19, N.Y. **(M)**

McBrien, Donald G., Research Associate in Photography, Optical Research Laboratory, Boston University. **Mail:** 28 Orchard Rd., Swampscott, Mass. **(A)**

Price, Robert S., General Engineer, Naval Ordnance Laboratory. **Mail:** 12 Mason Rd., Indian Head, Md. **(A)**

Richards, A. H., University of Southern California. **Mail:** 5356 Lexington, Apt. 108, Hollywood 29, Calif. **(S)**

Richardson, Norman, Photographer, Sandia Corp. **Mail:** Box 529, Brawley, Calif. **(A)**

Robertson, Robert B., Laboratory Technician, Consolidated Film Industries. **Mail:** 1622 North Dillon St., Los Angeles 26, Calif. **(M)**

Rouden, Manzia V., Motion Picture Technical Advisor, U.S. Air Force. **Mail:** Star Route, Santa Rosa, Fla. **(A)**

Sherman, Mendel, University of Southern California. **Mail:** 2625½ Ellendale Place Los Angeles 7, Calif. **(S)**

Snook, Mary Jean, Research Librarian, Technicolor Motion Picture Corp., 6311 Romaine St., Hollywood 38, Calif. **(A)**

Stein, Morton, Sales, Ray Mercer & Co. **Mail:** 9075 W. Pico Blvd., Los Angeles, Calif. **(A)**

Weitz, Loyal, University of Southern California. **Mail:** 1909 Farrell, Redondo Beach, Calif. **(S)**

Whipple, Paul E., University of Southern California. **Mail:** 3436 North Earle Ave., Rosemead, Calif. **(S)**

Wihtol, Constantine A., New York University. **Mail:** 108-10 — 66 Ave., Forest Hills, N.Y. **(S)**

Williams, Marshall A., Electronic Engineer, Philco Corp., 260 South Beverly Dr., Beverly Hills, Calif. **(M)**

Williamson, Harold G., Instrumentation Engineer, Vitro Corporation of America. **Mail:** General Delivery, Fort Walton, Fla. **(A)**

Wilson, James V., Chief Engineer, Film Laboratories of Canada, Ltd. **Mail:** 289 Forman Ave., Toronto, Ontario, Canada. **(M)**

Wolff, Leonard E., Audio Engineer, The Houston Post Co., KPRC-TV. **Mail:** 11401 O'Donnell Dr., Houston 22, Tex. **(A)**

CHANGES IN GRADE

Florman, Arthur, (A) to (M)
Goldberg, Morris M., (A) to (M)
Kuzmanov, Alexander B., (S) to (M)
Ricci, Eduardo J., (S) to (A)

DECEASED

Parshley, Charles W., Chief Projectionist, University Theater, Harvard Sq., Cambridge, Mass. **(A)**

Membership Service Questionnaire

Following through after the extensive discussion about cost, type and quality of membership service at the October 1952 Board of Governors Meeting, Society headquarters mailed a questionnaire early this month, with the annual membership dues invoices, to all members, except Students, in the United States. The earlier mailing date for invoices to members outside the United States did not permit sending questionnaires to them.

Within the ensuing two weeks about six hundred members replied. The volume of returns is gratifying and confirms the fact that the SMPTE is a membership society. The exactness and thoughtfulness of the replies will add up to a valuable guide to confirm some, and modify other, SMPTE policies.

If you have not returned your questionnaire, please send it along. The tally for a report to the Board of Governors and in the *Journal* to the membership will not be closed for a few weeks. Comments and suggestions are always gratefully received, especially suggestions and leads for technical papers or new products items.—V.A.

Book Review

Musical Engineering

By Harry F. Olson. Published (1952) by McGraw-Hill, 330 W. 42 St., New York 36. i-ix + 357 pp. + 11-pp. index. 303 illus. 6 × 9 in. Price $6.50.

An encyclopedic volume, even a compressed one, cannot help but strike a responsive chord within a wide range of engineers when it is as carefully prepared as this one. The engineering bases for approaching music will be nothing new to the acoustics engineer but others will find the engineering principles and the surrounding meat of the text often of great interest and nicely, if not too simply and disarmingly, presented. The attention of the general reader and the acoustics engineer alike may be held by the wealth and width of this survey. The acoustics engineer, and many of his fellow engineers in other fields, will find ample bibliographical references throughout to guide them to detailed studies. As far as periodicals go, the *Journal of the Acoustical Society* is most often cited, with this *Journal* a strong second in parts of the book.

For fuller technical explanations, the author often gives as a general reference his earlier book, *Elements of Acoustical Engineering*. The author is director of the Acoustical Laboratory, RCA Laboratories, Princeton, N.J.

To carry out its aim — an engineering treatment of the interrelated subjects of music, musical instruments, acoustics, sound reproduction and hearing — the book is organized in these nine chapters: Sound Waves; Musical Terminology; Scales; Resonators and Radiators; Musical Instruments; Characteristics of Musical Instruments; Properties of Music; Theater, Studio and Room Acoustics; and Sound Reproducing Systems. The numerous illustrations and the index contribute to the book's worthiness.—V.A.

Meetings

American Institute of Electrical Engineers (Symposium on the Science of Music and Its Reproduction — 4th Lecture), Feb. 20, Engineering Societies Bldg., New York, N. Y.

National Electrical Manufacturers Association, Mar. 9-12, Edgewater Beach Hotel, Chicago, Ill.

Society of Motion Picture and Television Engineers, Southwest Subsection Meeting, Mar. 16, Fort Worth, Tex.

Inter-Society Color Council, Annual Meeting, Mar. 18, Hotel Statler, New York, N. Y.

Optical Society of America, Mar. 19–21, Hotel Statler, New York, N.Y.

American Physical Society, Joint Meeting with APS Southeastern Section, Mar. 26–28, Duke University, Durham, N.C.

Symposium on Modern Network Synthesis, planned by Polytechnic Institute of Brooklyn, Apr. 16–18, Auditorium of Engineering Societies Bldg., New York

International Symposium on Nonlinear Circuit Analysis, Apr. 23–24, information from Microwave Research Inst., 55 Johnson St., Brooklyn 1, N.Y.

73d Semiannual Convention of the SMPTE, Apr. 27–May 1, Hotel Statler, Los Angeles

National Association of Radio and Television Broadcasters, 7th Annual Conf., Apr. 28–May 1, Ambassador Hotel, Los Angeles

American Physical Society, Apr. 30–May 2, Washington, D.C.

Acoustical Society of America, May 7–9, Hotel Warwick, Philadelphia, Pa.

Society of Motion Picture and Television Engineers, Southwest Subsection, May 20, Dallas, Tex.

American Physical Society, June 18–20, Rochester, N.Y.

American Institute of Electrical Engineers, Summer General Meeting, June 29–July 3, Atlantic City, N.J.

Biological Photographic Association, 23d Annual Meeting, Aug. 31–Sept. 3, Hotel Statler, Los Angeles, Calif.

The Royal Photographic Society's Centenary, International Conference on the Science and Applications of Photography, Sept. 19–25, London, England

74th Semiannual Convention of the SMPTE, Oct. 4–9, Hotel Statler, New York

Audio Engineering Society, Fifth Annual Convention, Oct. 14–17, Hotel New Yorker, New York, N.Y.

Theatre Equipment and Supply Manufacturers' Association Convention (in conjunction with Theatre Equipment Dealers' Association and Theatre Owners of America), Oct. 31–Nov. 4, Conrad Hilton Hotel, Chicago, Ill.

Theatre Owners of America, Annual Convention and Trade Show, Nov. 1–5, Chicago, Ill.

National Electrical Manufacturers Association, Nov. 9–12, Haddon Hall Hotel, Atlantic City, N.J.

75th Semiannual Convention of the SMPTE, May 3–7, 1954 (next year), Hotel Statler, Washington, D.C.

76th Semiannual Convention of the SMPTE, Oct. 18–20, 1954 (next year), Ambassador Hotel, Los Angeles

Employment Service

Position Wanted

Resigning Feb. 1 as gen. mgr., charge of production, large southern film studio. 15 yrs. experience as prod. mgr., editor and cameraman, 16mm and 35mm. Married, 37, college grad. References and résumé on request — Harlan H. Mendenhall, 1609 Blodgett, Houston 4, Tex.

Position Available

Permanent position in Southwest for experienced motion picture cameraman; must have sample interior and exterior footage to indicate ability. Write letter, giving résumé of professional experience, to Susong Agency, 524 Commercial Bldg. Dallas, Tex. All replies confidential.

New Products

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products.

A collapsible three-wheel camera dolly has been designed to fold into a case 20 × 20 × 36 in. It is made of cast aluminum. The center mount casting provides a hook for optional use of the tie-down chains when using standard or baby tripods, and additional baby tripod point holders are provided. Extra-wide rubber wheels have been used to prevent side sway. The new dolly has floor hand jackscrews for leveling or stationary position, foot tread plates for the cameraman and the assistant cameraman, adjustable seat for the operator, a removable steering handle and a lock for in-line steering. The dolly is manufactured by National Cine Equipment, Inc., 209 W. 48 St., New York 36, N.Y.

A new motion picture projection lamp has been developed by the Westinghouse Lamp Division, with the assistance of Bell & Howell engineers. Reported to improve home motion picture screen light by as much as 20%, it is to be incorporated in Bell & Howell's projectors. Increased efficiency is reported achieved by a more compact biplane filament made by tighter winding and closer spacing of the coils which in turn is made possible by Westinghouse's patented Floating Bridge, a supporting and guiding device for the coils. An improved quality of filament wire is also cited as a factor in increasing the output and life of the lamps which are now made in 500- and 750-w sizes. A 1000-w lamp is being studied as a possible future development.

The intensity of light from mercury-arc lamps can now be stabilized by photocell control in a combination recently developed by Hanovia Chemical & Mfg. Co., 100 Chestnut St., Newark, N.J. This new light source is marketed for use in photochemical research and motion picture printing. A photoelectric cell in the power supply through an electronic circuit, controls the arc current in a range from maximum to about 10% of maximum. These wide limits are attainable because the heat of the electric arc is no longer utilized to maintain the internal vapor pressure, which now depends on auxiliary heating elements.

SMPTE Officers and Committees: The roster of Society Officers and the Committee Chairmen and Members were published in the April 1952 *Journal*.

Society of Motion Picture and Television Engineers

40 West 40th Street, New York 18, N. Y., Tel. LOngacre 5-0172
Boyce Nemec, *Executive Secretary*

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Theatre Holding Corporation
Titra Film Laboratories, Inc.
United Amusement Corp., Ltd.
Westinghouse Electric Corporation
Westrex Corporation
Wilding Picture Productions, Inc.
Wollensak Optical Company